

Guide to the Geology of Garden of the Gods Area, Gallatin, Hardin, Pope, and Saline Counties, Illinois

Wayne T. Frankie and Russell J. Jacobson




Field Trip Guidebook 2001A	April 14, 2001
Field Trip Guidebook 2001B	May 12, 2001

George H. Ryan, Governor

Department of Natural Resources
Brent Manning, Director

ILLINOIS STATE GEOLOGICAL SURVEY
William W. Shilts, Chief



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Geological Science Field Trips The Geoscience Education and Outreach Unit of the Illinois State Geological Survey (ISGS) conducts four free tours each year to acquaint the public with the rocks, mineral resources, and landscapes of various regions of the state and the geological processes that have led to their origin. Each trip is an all-day excursion through one or more Illinois counties. Frequent stops are made to explore interesting phenomena, explain the processes that shape our environment, discuss principles of earth science, and collect rocks and fossils. People of all ages and interests are welcome. The trips are especially helpful to teachers who prepare earth science units. Grade school students are welcome, but each must be accompanied by a parent or guardian. High school science classes should be supervised by at least one adult for each ten students.

A list of guidebooks of earlier field trips for planning class tours and private outings may be obtained by contacting the Geoscience Education and Outreach Unit, Illinois State Geological Survey, Natural Resources Building, 615 East Peabody Drive, Champaign, IL 61820-6964. (Telephone: (217) 244-2427 or 333-4747). This information is on the ISGS home page: <http://www.isgs.uiuc.edu>

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Era	Period or System and Thickness	Epoch	Age (years ago)	General Types of Rocks	
CENOZOIC "Recent Life"	Quaternary 0-500'	Holocene	10,000	Recent— alluvium in river valleys	
		Pleistocene Glacial Age		Glacial till, glacial outwash, gravel, sand, silt, lake deposits of clay and silt, loess and sand dunes; covers nearly all of state except north-west corner and southern tip	
	Tertiary 0-500'	Pliocene	1.6 m 5.3 m 36.6 m	Chert gravel, present in northern, southern, and western Illinois	
		Eocene		Mostly micaceous sand with some silt and clay; presently only in southern Illinois	
	Paleocene		57.8 m 66.4 m	Mostly clay, little sand; present only in southern Illinois	
MESOZOIC "Middle Life"	Cretaceous 0-300'		[144 m 286 m]	Mostly sand, some thin beds of clay, and, locally, gravel, present only in southern Illinois	
PALEOZOIC "Ancient Life"	Pennsylvanian 0-3,000' ("Coal Measures")			Largely shale and sandstone with beds of coal, limestone, and clay	
			320 m		
	Mississippian 0-3,500'			Black and gray shale at base, middle zone of thick limestone that grades to siltstone chert, and shale; upper zone of interbedded sandstone, shale, and limestone	
			360 m		
	Devonian 0-1,500'			Thick limestone, minor sandstones and shales; largely chert and cherty limestone in southern Illinois; black shale at top	
			408 m		
	Silurian 0-1,000'			Principally dolomite and limestone	
			438 m		
	Ordovician 500-2,000'			Largely dolomite and limestone but contains sandstone, shale, and siltstone formations	
			505 m		
	Cambrian 1,500-3,000'			Chiefly sandstones with some dolomite and shale; exposed only in small areas in north-central Illinois	
			570 m		
	Precambrian			Igneous and metamorphic rocks; known in Illinois only from deep wells	

Generalized geologic column showing succession of rocks in Illinois.

GARDEN OF THE GODS AREA

The Garden of the Gods Area, located in the part of southern Illinois never reached by continental glaciers, is one of the state's most scenic and geologically complex areas. This geological science field trip will acquaint you with the *geology*,¹ landscape, and mineral resources of parts of Gallatin, Hardin, Pope, and Saline Counties, Illinois. Harrisburg, the largest city within the field trip area, is approximately 332 miles south of Chicago, 187 miles southeast of Springfield, 129 miles southeast of East St. Louis, and 81 miles northeast of Cairo.

GEOLOGIC FRAMEWORK

Precambrian Era

Through several billion years of geologic time, the area surrounding the Garden of the Gods Recreation Area has undergone many changes (see the rock succession column, facing page). The oldest rocks beneath the field trip area belong to the ancient Precambrian *basement complex*. We know relatively little about these rocks from direct observations because they are not exposed at the surface anywhere in Illinois. Only about 35 drill holes have reached deeply enough for geologists to collect samples from Precambrian rocks of Illinois. From these samples, however, we know that these ancient rocks consist mostly of granitic and rhyolitic *igneous*, and possibly *metamorphic*, crystalline rocks formed about 1.5 to 1.0 billion years ago. From about 1 billion to about 0.6 billion years ago, these Precambrian rocks were exposed at the surface. During this long period, the rocks were deeply weathered and eroded and formed a barren landscape that was probably quite similar to the *topography* of the present Missouri Ozarks. We have no rock record in Illinois for the long interval of *weathering* and erosion that lasted from the formation of the Precambrian rocks until the first Cambrian age *sediments* accumulated, but that interval is almost as long as the time from the beginning of the Cambrian *Period* to the present.

Because geologists cannot see the Precambrian basement rocks in Illinois except as cuttings and cores from boreholes, various other techniques must be used, such as measurements of Earth's gravitational and magnetic fields, and seismic exploration, to map out the regional characteristics of the basement complex. The evidence collected with these techniques indicates that in southernmost Illinois, near what is now the historic Kentucky-Illinois fluorspar mining district, *rift* valleys similar to those in east Africa formed as movement of crustal plates (plate *tectonics*) began to rip apart the Precambrian continent that became North America. These rift valleys in the midcontinent region are referred to as the Rough Creek *Graben* and the Reelfoot Rift (fig. 1).

Paleozoic Era

After the beginning of the Paleozoic Era, about 520 million years ago in the late Cambrian Period, the rifting stopped, and the hilly Precambrian landscape began to sink slowly on a broad regional scale, allowing the invasion of a shallow sea from the south and southwest. During the 280 million years of the Paleozoic Era, the area that is now called the Illinois *Basin* continued to accumulate sediments that were deposited in the shallow seas that repeatedly covered this subsiding basin. The region continued to sink until at least 20,000 feet of sedimentary strata were deposited in the deepest part of the basin, located in the Rough Creek Graben area of southeastern Illinois and western Kentucky. At various times during this era, the seas withdrew and deposits were weathered and eroded. As a result, there are gaps in the sedimentary record in Illinois.

¹ Words in italics are defined in the glossary at the back of the guidebook. Also please note that, although all present localities have only recently appeared within the geologic time frame, we use the present names of places and geologic features because they provide clear reference points for describing the ancient landscape.

In the field trip area, *bedrock* strata range in age from more than 520 million years old (the Cambrian Period) to less than 320 million years old (the Pennsylvanian Period). Figure 2 shows the succession of rock strata a drill bit would penetrate in this area if the rock record were complete and all the *formations* were present. The oldest Paleozoic rocks exposed in the area are Devonian in age. They formed from sediments that accumulated from about 385 million years ago up to 360 million years ago.

Within the field trip area, the depth to the Precambrian basement rocks is significantly offset by the Shawneetown *Fault*. North of the Shawneetown Fault Zone, where the fault crosses between Gallatin and Saline Counties, the elevation of the top of the Precambrian basement rocks is a little more than 14,000 feet below sea level, and the Paleozoic sedimentary strata deposited on top of the Precambrian total at least 15,000 feet in thickness. Nearby, on the south side of the Shawneetown Fault Zone, the elevation of the top of the Precambrian basement rocks is more than 18,000 feet below sea level, and the Paleozoic sedimentary strata deposited on top of the Precambrian basement are at least 19,000 feet thick.

DEPOSITIONAL HISTORY

As noted previously, the Rough Creek Graben and the Reelfoot Rift (figs. 1 and 3) were formed by tectonic activity that began in the latter part of the Precambrian Era and continued until the Late Cambrian. Toward the end of the Cambrian, rifting ended, and the whole region began to subside, allowing shallow seas to cover the land.

Paleozoic Era

From the Late Cambrian to the end of the Paleozoic Era, sediments continued to accumulate in the shallow seas that repeatedly covered Illinois and adjacent states. These inland seas connected with the open ocean to the south during much of the Paleozoic, and the area that is now southern Illinois was similar to an embayment. The southern part of Illinois and adjacent parts of Indiana and Kentucky sank more rapidly than the areas to the north, allowing thicker sediment accumulations. During the Paleozoic and Mesozoic, the Earth's thin crust was periodically flexed and warped in places as stresses built up in response to the tectonic forces associated with the collision of continental and oceanic plates and mountain building. These movements caused repeated invasions and withdrawals of the seas across the region. The former sea floors were thus periodically exposed to erosion, which removed some sediments from the rock record.

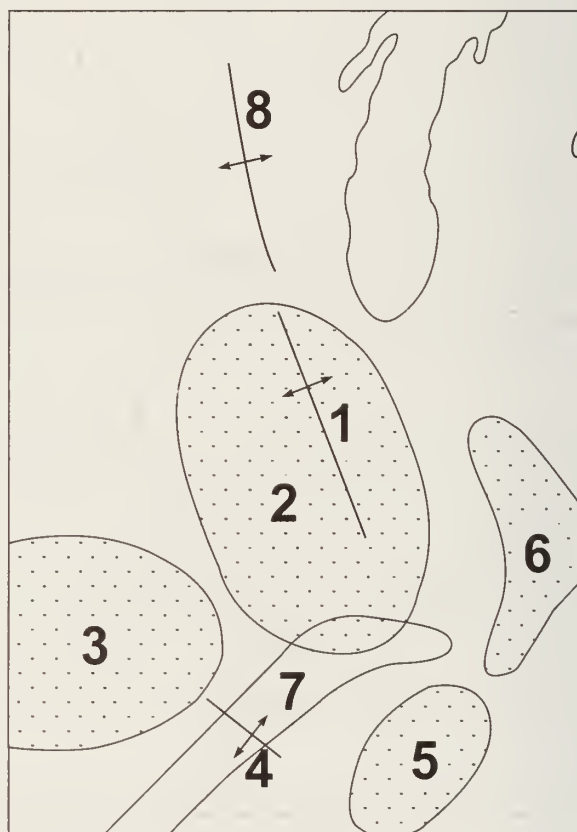


Figure 1 Location of some of the major structures in the Illinois region. (1) La Salle Anticlinorium, (2) Illinois Basin, (3) Ozark Dome, (4) Pascola Arch, (5) Nashville Dome, (6) Cincinnati Arch, (7) Rough Creek Graben–Reelfoot Rift, and (8) Wisconsin Arch.

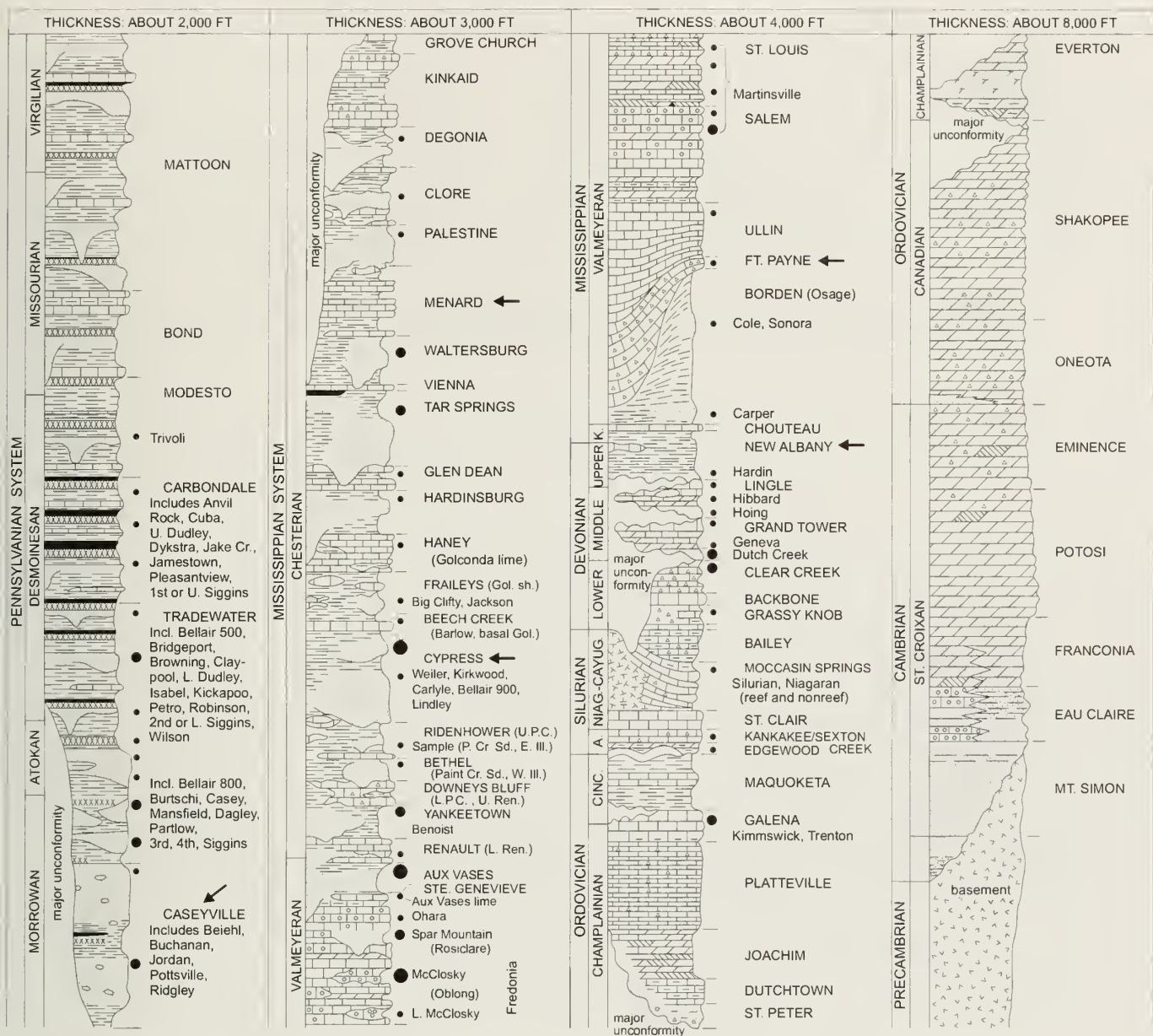


Figure 2 Generalized stratigraphic column of the field trip area. Black dots indicate oil and gas pay zones (variable vertical scale). Arrows indicate major units seen on the field trip (modified from Leighton et al. 1991).

Many of the sedimentary units, called formations, have conformable contacts—that is, no significant interruption in deposition occurred as one formation was succeeded by another (figs. 2 and 4). In some instances, even though the composition and appearance of the rocks change significantly at the contact between two formations, the *fossils* in the rocks and the relationships between the rocks at the contact indicate that deposition was virtually continuous. In contrast, however, in some places, the top of the lower formation was at least partially eroded before deposition of the next formation began. In these instances, fossils and/or other evidence within or at the boundary between the two formations indicate a significant age difference between the lower unit and the overlying unit. This type of contact is called an *unconformity* (fig. 4). If the *beds* above and below an unconformity are parallel, the unconformity is called a *disconformity*. However, if the lower beds were tilted and eroded prior to deposition of overlying beds, the contact is called an angular unconformity.

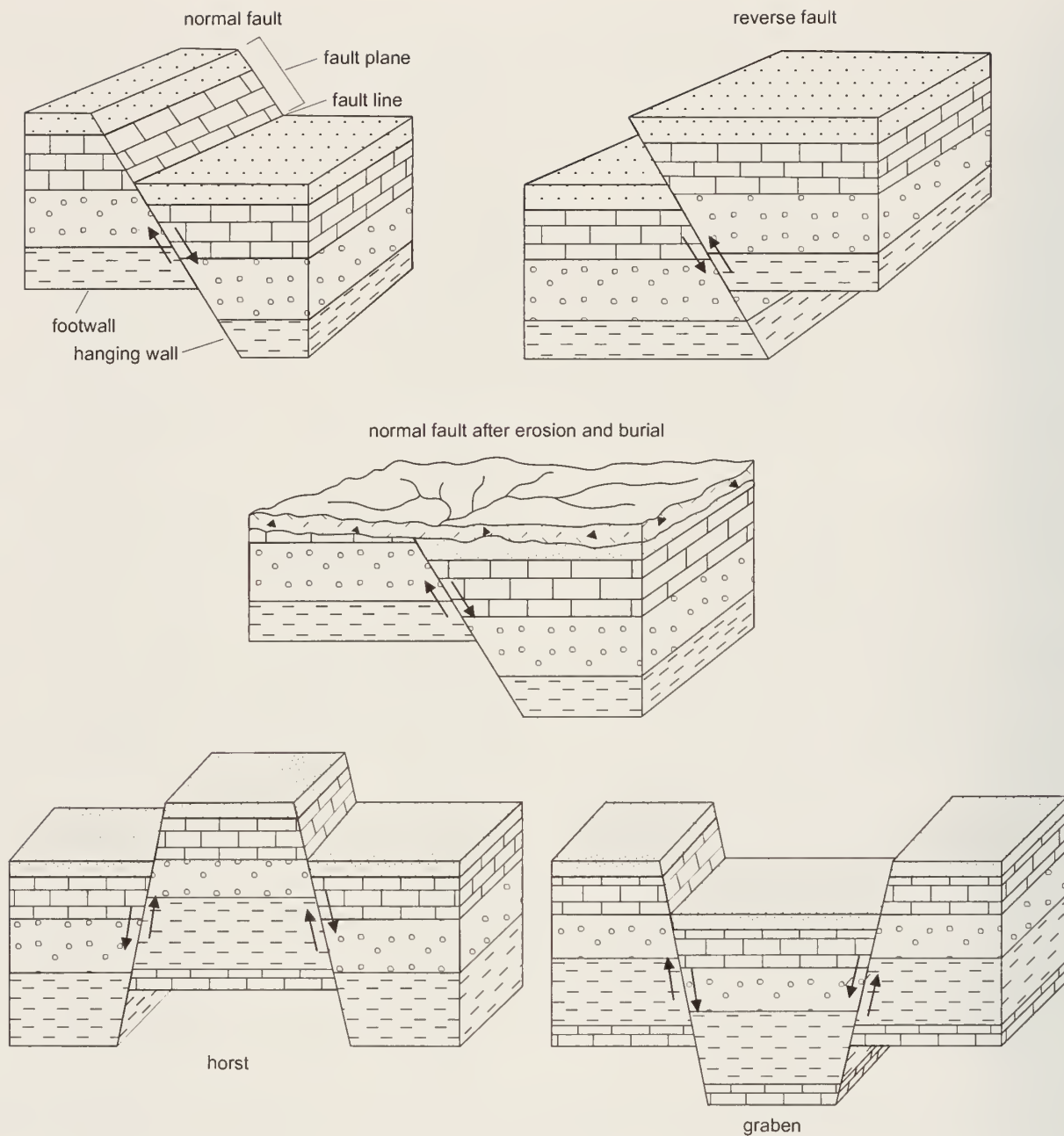


Figure 3 Diagrammatic illustrations of fault types that may be present in the field trip area. A fault is a fracture in the earth's crust along which there has been relative movement of the opposing blocks. A fault is usually an inclined plane, and when the hanging wall (the block above the plane) has moved up relative to the footwall (the block below the fracture), the fault is a reverse fault. When the hanging wall has moved down relative to the footwall, the fault is a normal fault.

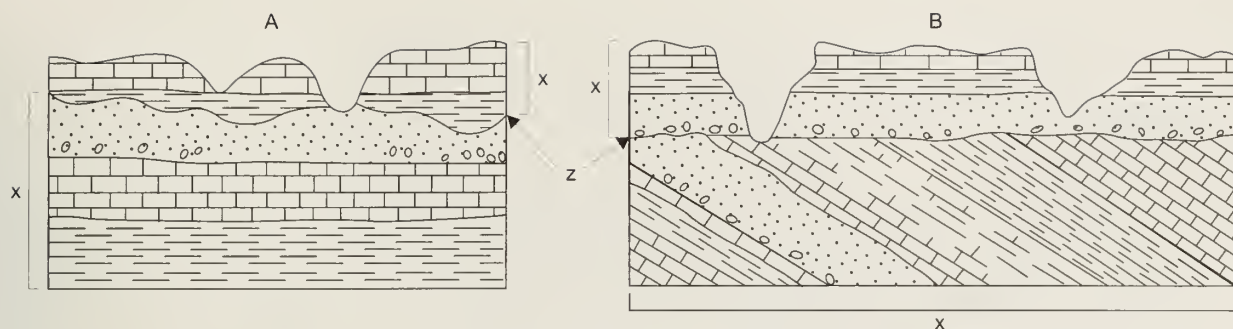


Figure 4 Schematic drawings of (A) a disconformity and (B) an angular unconformity (x represents the conformable rock sequence, and z is the plane of unconformity).

Unconformities occur throughout the Paleozoic rock record and are shown as wavy lines in the generalized stratigraphic column in figure 2. Each unconformity represents an extended interval of time for which there is no rock record.

Near the close of the Mississippian Period, gentle arching of the rocks in eastern Illinois initiated the development of the La Salle *Anticlinorium* (figs. 1 and 5). An anticlinorium is a complex structure having smaller structures such as domes, *anticlines*, and *synclines* superimposed on the broad upwarp of the anticlinorium. Further gradual arching continued through the Pennsylvanian Period. Because the youngest Pennsylvanian strata are absent from the area of the anticlinorium (either because they were not deposited or because they were later eroded), we cannot determine just when folding ceased—perhaps by the end of the Pennsylvanian or a little later during the Permian Period, near the close of the Paleozoic Era.

Mesozoic Era

During the Mesozoic Era, the rise of the Pascola Arch (figs. 1 and 5) in southeastern Missouri and western Tennessee produced a structural barrier that helped form the current shape of the Illinois Basin by closing off the embayment and separating it from the open sea to the south. The Illinois Basin is a broad, subsided region covering much of Illinois, southwestern Indiana, and western Kentucky (fig. 1). Development of the Pascola Arch, in conjunction with the earlier sinking of the deeper portion of the basin north of the Pascola Arch in southern Illinois, gave the basin its present asymmetrical, spoon-shaped configuration (fig. 6). The geologic map (fig. 7) shows the distribution of the rock *systems* of the various geologic time periods as they would appear if all the glacial, windblown, and other surface materials were removed.

Younger rocks of the latest Pennsylvanian and perhaps the Permian (the youngest rock systems of the Paleozoic) may have at one time covered the southern portion of Illinois. Mesozoic and Cenozoic rocks (see the generalized geologic column) possibly could have been present here also. Indirect evidence, based on the stage of development (rank) of coal deposits and the generation and maturation of petroleum from source rocks (Damberger 1971), indicates that perhaps as much as 1.5 miles of rocks of the latest Pennsylvanian and younger once covered southern Illinois. During the more than 240 million years since the end of the Paleozoic Era (and before the onset of *glaciation* 1 to 2 million years ago), however, several thousands of feet of strata may have been eroded. Nearly all traces of any post-Pennsylvanian bedrock that may have been present in Illinois were removed. During this extended period of erosion, deep valleys were carved into the gently tilted bedrock formations (fig. 8). Later, the topographic *relief* was reduced by the repeated advances and melting back of continental *glaciers* that scoured and scraped the bedrock surface.

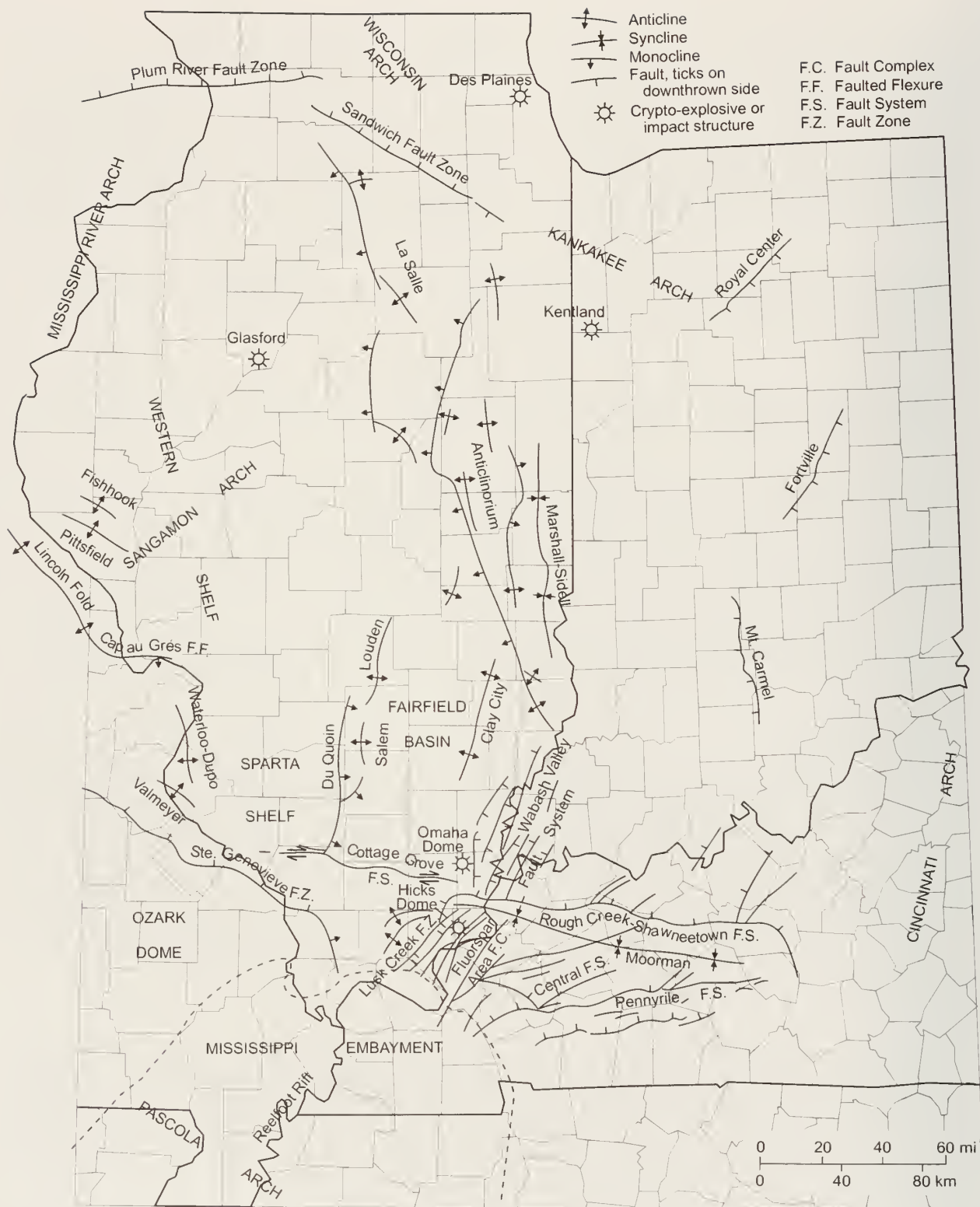


Figure 5 Structural features of Illinois (modified from Buschbach and Kolata 1991).

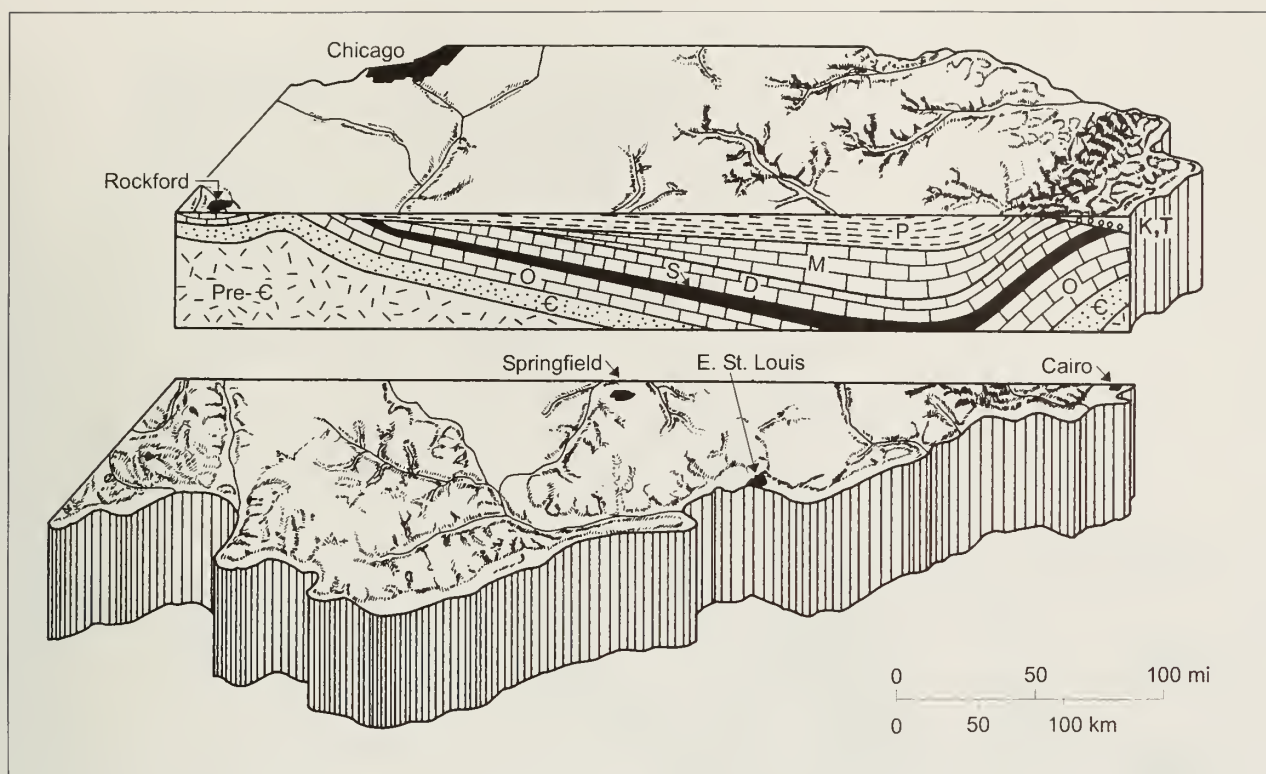


Figure 6 Stylized north-south cross section shows the structure of the Illinois Basin. To show detail, the thickness of the sedimentary rocks has been greatly exaggerated and younger, unconsolidated surface deposits have been eliminated. The oldest rocks are Precambrian (Pre Є) granites. They form a depression filled with layers of sedimentary rocks of various ages: Cambrian (Є), Ordovician (O), Silurian (S), Devonian (D), Mississippian (M), Pennsylvanian (P), Cretaceous (K), and Tertiary (T). Scale is approximate.

This glacial erosion and deposition affected all the formations exposed at the bedrock surface in Illinois. The final melting of the glaciers left behind the *non-lithified* deposits in which our modern soil has developed.

STRUCTURAL SETTING

The Garden of the Gods field trip area is located in the southeast corner of the Illinois Basin, in southeast Saline, southwest Gallatin, northeast Pope, and northwest Hardin Counties. The Illinois Basin is the major structural depression between the Ozark Dome and the Cincinnati Arch (fig. 1).

Shawneetown Fault Zone

The Rough Creek–Shawneetown Fault System is located in northeastern Pope, southeastern Saline, and southern Gallatin Counties (see fig. 5). The name Shawneetown Fault Zone is applied to the portion of the Rough Creek–Shawneetown Fault System that is in Illinois (fig. 9). The following description of the Shawneetown Fault Zone is modified from that of Nelson (1995).

The Shawneetown Fault Zone enters Illinois just south of Old Shawneetown in Gallatin County and trends westward for about 15 miles. In southeastern Saline County, the fault zone curves sharply to the south-southwest and continues about 12 more miles to Section 25, T11S, R6E, in Pope County, where it intersects the Lusk Creek Fault Zone (fig. 9). Along most of its length, the Shawneetown Fault Zone is well expressed topographically by a range of hills of resistant lower

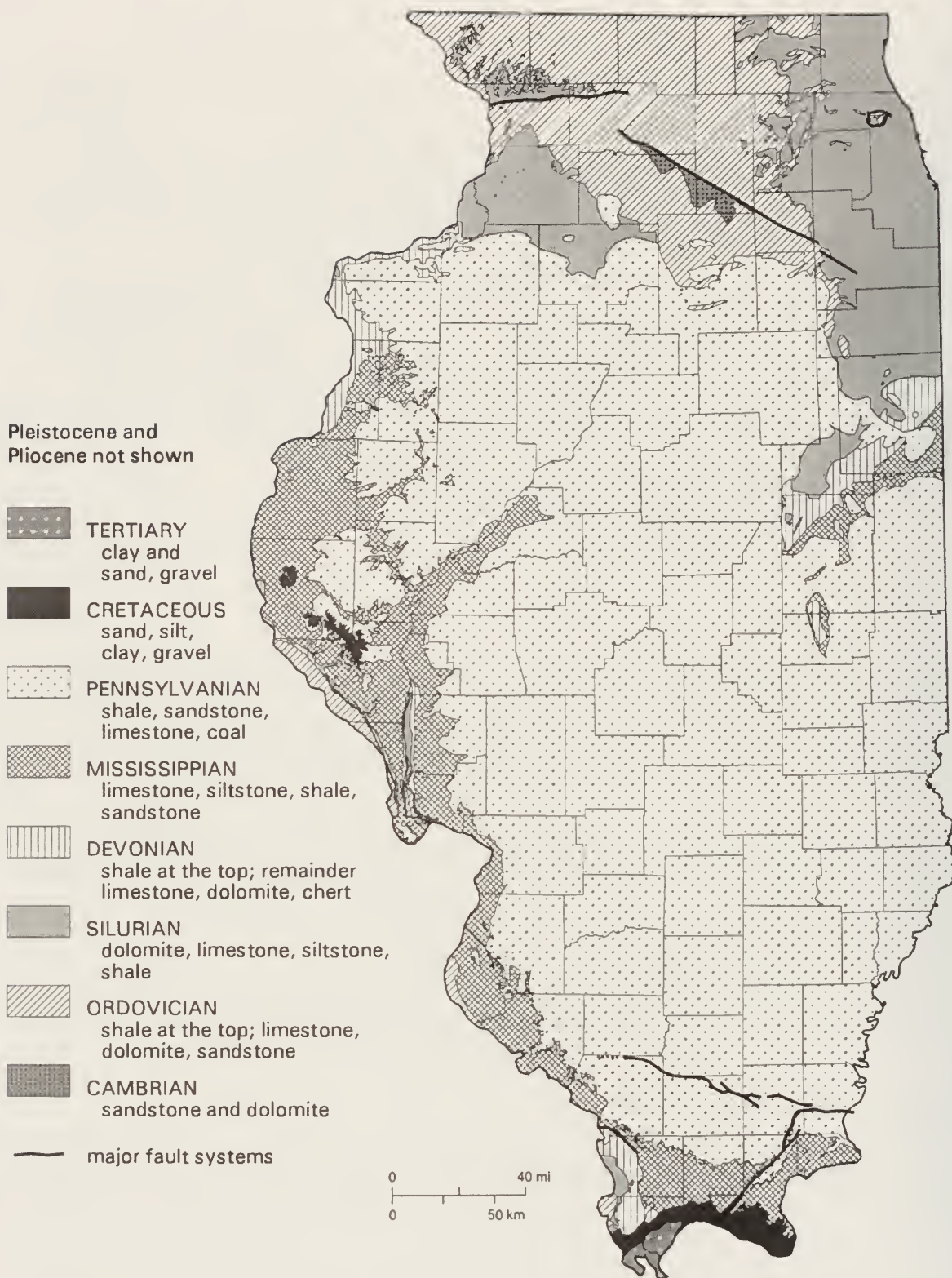


Figure 7 Bedrock geology beneath surficial deposits in Illinois.

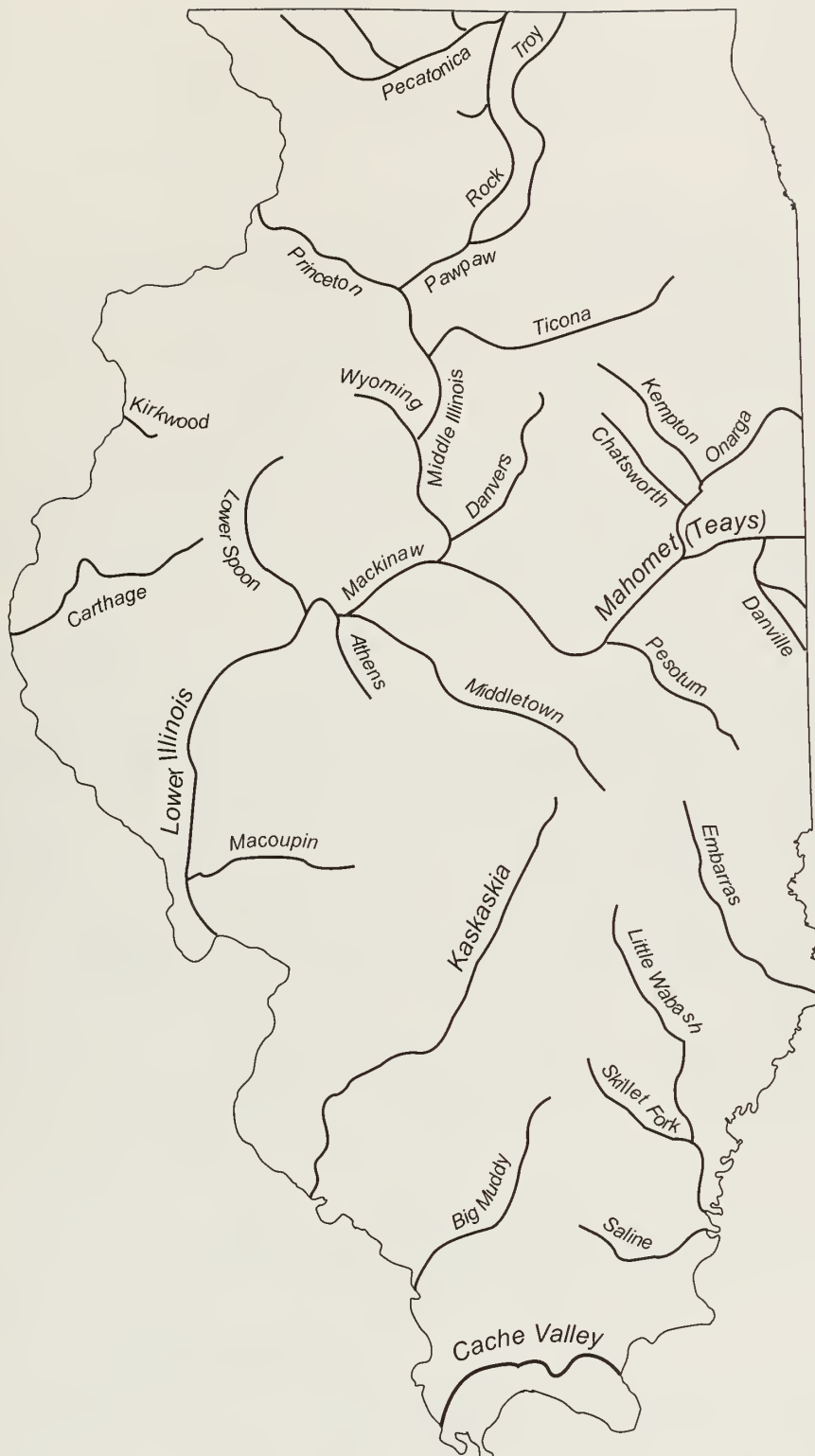


Figure 8 Major bedrock valleys of Illinois.

Pennsylvanian Caseyville Formation south and southeast of the fault zone. These include several of the highest points in southern Illinois: Williams Hill (elevation 1,064 feet), Horton Hill (elevation, 1,000 feet), Wamble Mountain (elevation, 940 feet), Cave Hill (elevation, 923 feet), and Bald Knob (820 feet). The fault zone itself tends to form a strike valley and is concealed by alluvium or *glacio-lacustrine* deposits in many places.

The fault zone ranges in width from a few yards to as much as 8,000 feet. The largest fault in the zone is near the north edge of the east-west-trending part of the zone and exhibits as much as 3,500 feet of vertical separation. This large fault is referred to as the Front Fault, and seismic data indicate that it continues the full length of the Rough Creek–Shawneetown Fault System in Kentucky (fig. 6). Data from wells drilled in this area show this to be a high-angle reverse fault dipping about 70°, to the south (see fig. 3).

Other faults in the Shawneetown Fault Zone strike subparallel to the Front Fault and have throws measured in hundreds of feet. Some of these join the Front Fault at one or both ends and probably connect with it at depth, but other faults appear to be isolated. In places, the fault zone assumes a braided pattern with interconnected faults outlining a series of polygonal or lens-shaped slices. Most of the smaller faults in the Shawneetown Fault Zone probably are *normal faults*.

Horseshoe Upheaval

Large displacements in the Shawneetown Fault Zone are the result of sharp tilting and upthrow of slices adjacent to the Front Fault. The most extreme case is at the Horseshoe Upheaval in Section 36, T9S, R7E (Stop 5), just west of the Saline-Gallatin county line (fig. 9). At this point, a slice of nearly vertical Mississippian Fort Payne Formation and Upper Devonian New Albany Group south of the Front Fault is juxtaposed with middle Pennsylvanian strata north of the fault (fig. 10). An oil test hole 0.75 mile west of the Horseshoe Upheaval penetrated the Front Fault and passed from Lower Devonian chert in the upper block into younger Pennsylvanian strata in the lower block (see figs. 2 and 3). The vertical separation is approximately 3,500 feet, which is the largest known offset on any near-surface fault in Illinois. At numerous other places, tilted blocks of Mississippian strata are upthrown between Pennsylvanian rocks along the fault zone.

Rocks north and northwest of the Shawneetown Fault Zone are mostly horizontal or dip gently to the north or northwest. In the fault slices and immediately south or southeast of the fault zone, the rocks generally dip steeply south or southeast and strike parallel with the faults. These dips rapidly diminish away from the fault zone.

The presence of the upthrown slices and the steep tilting of strata along the fault zone imply that two periods of movement took place after Pennsylvanian sedimentation. The first movement was reverse with the south or southeast side upthrown; the second movement involved normal faulting with the south or southeast side downdropped (figs. 3 and 10).

No oil production has been achieved in or south of the Shawneetown Fault Zone, although numerous fields have been developed in and south of the Rough Creek–Shawneetown Fault System in adjacent parts of Kentucky. Small-scale mining and prospecting for fluorite and associated minerals have taken place along the southwest-trending portion of the Shawneetown Fault Zone.

Eagle Valley Syncline

The Eagle Valley Syncline is the narrow western extension of the Moorman Syncline in Illinois (fig. 5). The Eagle Valley Syncline is located south of the Shawneetown Fault Zone in southeastern Saline and southern Gallatin Counties (fig. 9). The following description of the Eagle Valley Syncline is modified from Nelson (1995).

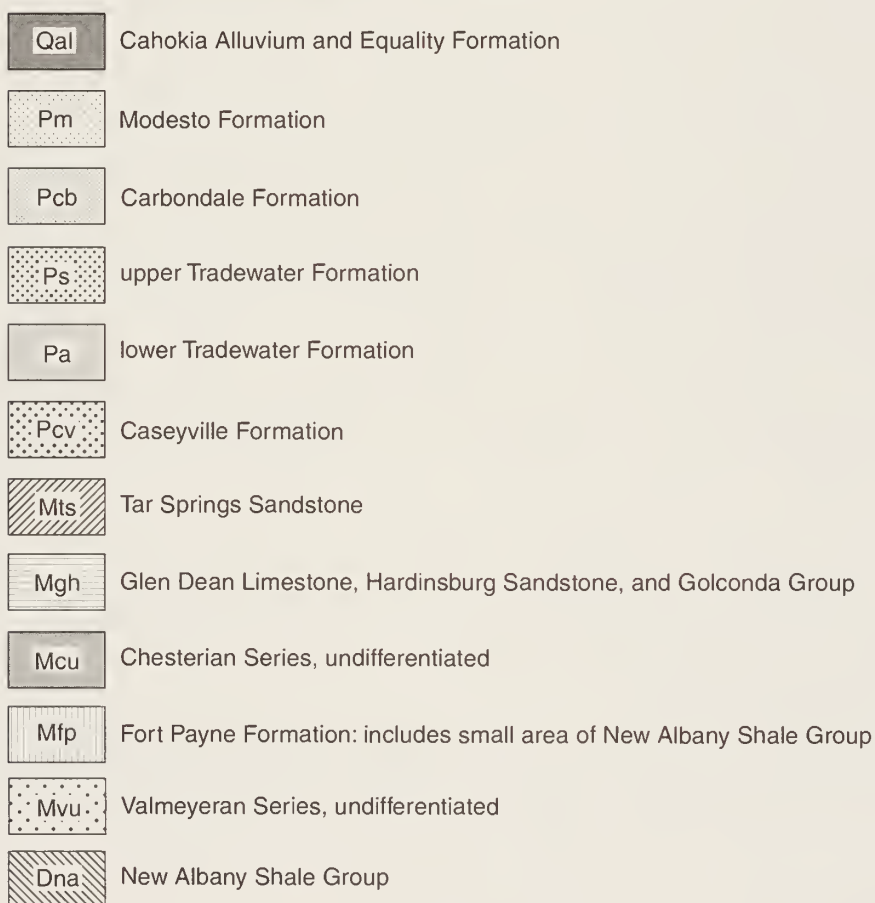
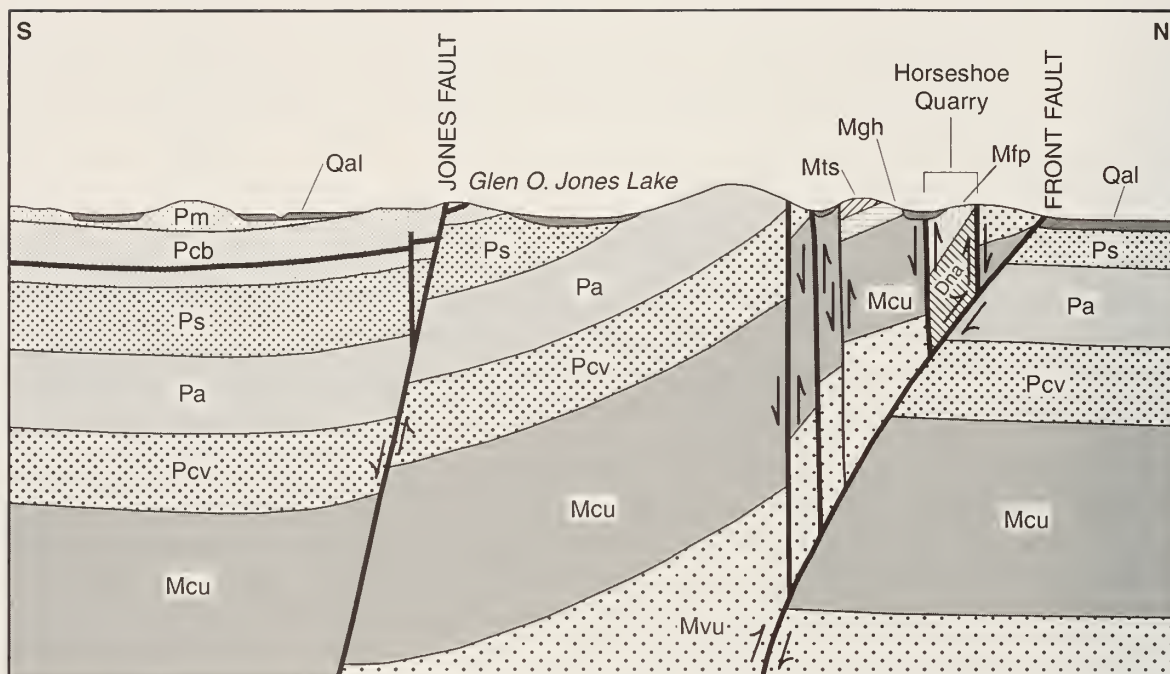


Figure 10 Shawneetown Fault Zone and its effect on the bedrock strata in the Horseshoe Upheaval (modified from Nelson and Lumm 1986).

The Eagle Valley Syncline lies immediately south of and trends approximately parallel with the east-west part of the Shawneetown Fault Zone. As defined, the Eagle Valley Syncline is about 15 miles in length, and its width increases from about 6 miles near the west end to about 9 miles at the Ohio River. It is abruptly closed off at the west end, where the Shawneetown Fault Zone turns to the southwest. The flanks are marked by rugged hills of resistant lower Pennsylvanian sandstone, whereas the central area is a lowland underlain by easily eroded and younger Pennsylvanian strata of the Carbondale Formation (fig. 11).

Although displacements on individual faults are large, the net offset across the Shawneetown Fault Zone is small. Pennsylvanian coal beds in the Eagle Valley Syncline south of the fault zone lie at the same or slightly lower elevation as the same beds north of the fault zone. However, detailed structural mapping, as measured on the Springfield (No. 5) Coal Member, reveals more than 2,000 feet of relief within the syncline. The axis is sinuous and contains several enclosed depressions. The south limb dips rather uniformly at 5° to 10°; dips on the north limb are much more variable, from less than 10° to 60° (locally steeper).

The north limb of the Eagle Valley Syncline was produced by displacement along the Rough Creek–Shawneetown Fault System. The south flank of the syncline merges with the north flank of Hicks Dome and the northeast flank of the Tolu Arch (fig. 9).

GLACIAL HISTORY OF ILLINOIS

Cenozoic Era

A brief general history of glaciation in North America and a description of the deposits commonly left by glaciers are given in *Quaternary Glaciations in Illinois* at the back of the guidebook.

As already stated, the erosion that took place long before the glaciers advanced across the state left a network of deep valleys carved into the bedrock surface (fig. 8). The present topography of Illinois is significantly different from the topography of the preglacial bedrock surface. The topography of the bedrock surface throughout much of Illinois is largely hidden from view by glacial deposits except along the major streams and in the driftless areas of northwestern, western, and southern Illinois (fig. 12). In many areas, the glacial drift is thick enough to completely mask the underlying bedrock surface. Studies of mine shafts, water-well logs, and other drill-hole information, in addition to scattered bedrock exposures in some stream valleys and roadcuts, show that the present land surface of the glaciated areas of Illinois does not reflect the underlying bedrock surface. The topography of the preglacial bedrock surface has been significantly modified by glacial erosion and is subdued by glacial deposits.

In the past 1.6 million to 2 million years—during the Pleistocene *Epoch* of the Quaternary Period—much of northern North America was repeatedly covered by huge glaciers (see *Quaternary Glaciations* in the back of the guidebook). These continent-size masses of ice formed in eastern and central Canada as a result of climate cooling. Glacial advances into the central lowland of the United States altered the landscape across much of the Midwest.

During an early part of the Pleistocene Epoch, glaciers advanced out of centers of ice accumulation both east and west of the Hudson Bay area in Canada. These centers are referred to in this guidebook as northeastern and northwestern source areas because Illinois lies to the south of and between these centers of accumulation. Glaciers flowing out of these centers into Illinois carried along rock debris incorporated into the ice as they advanced; this material was dropped out as the ice melted. The number and timing of these early episodes of glaciation are uncertain at present and are therefore unnamed, but, because they precede the first named episode of glaciation (the

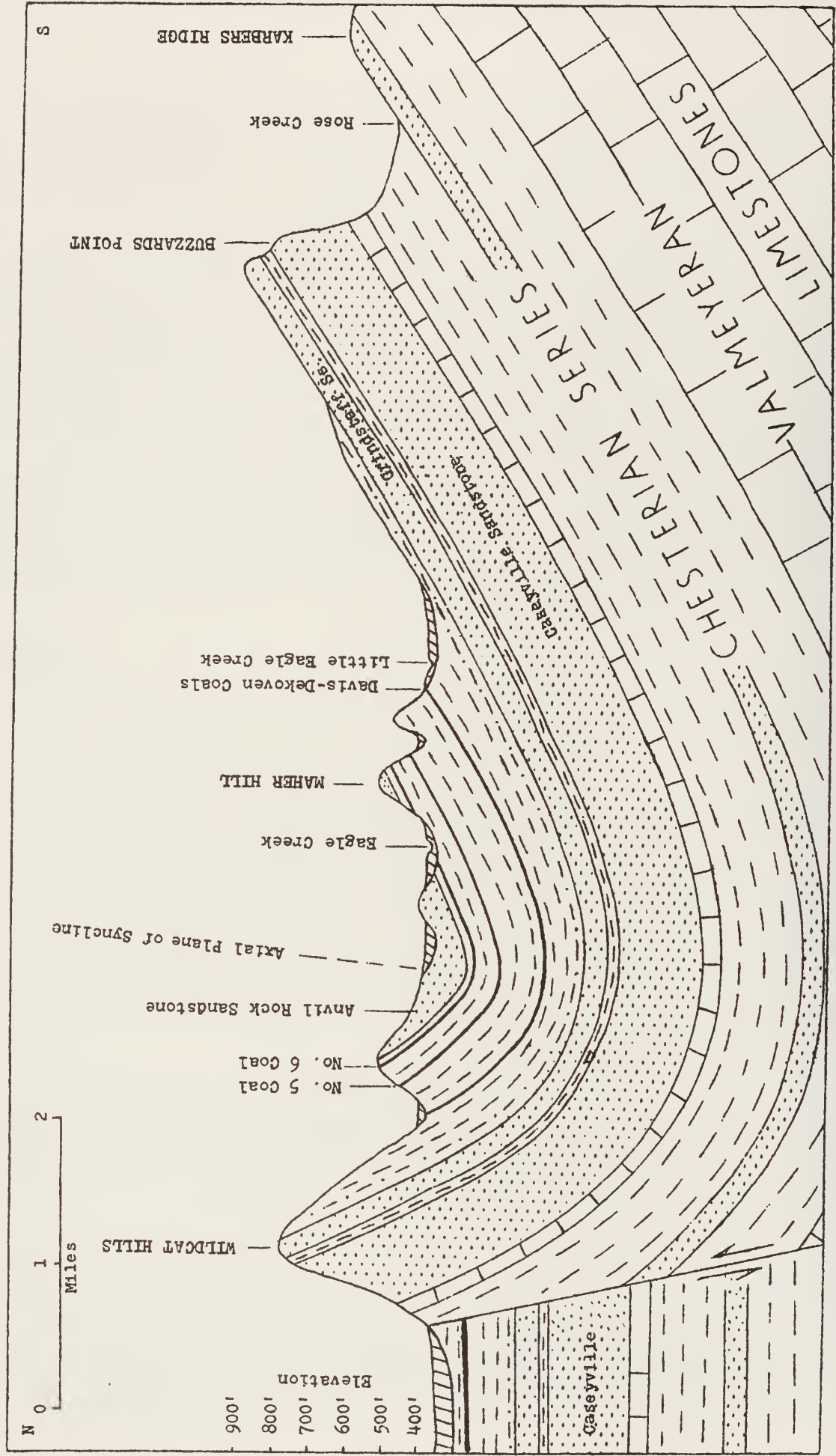


Figure 11 Generalized cross section through Eagle Valley Syncline, from Wildcat Hills just south of Equality to Karbers Ridge near Garden of the Gods Recreation Area. Vertical scale and dips are greatly exaggerated.

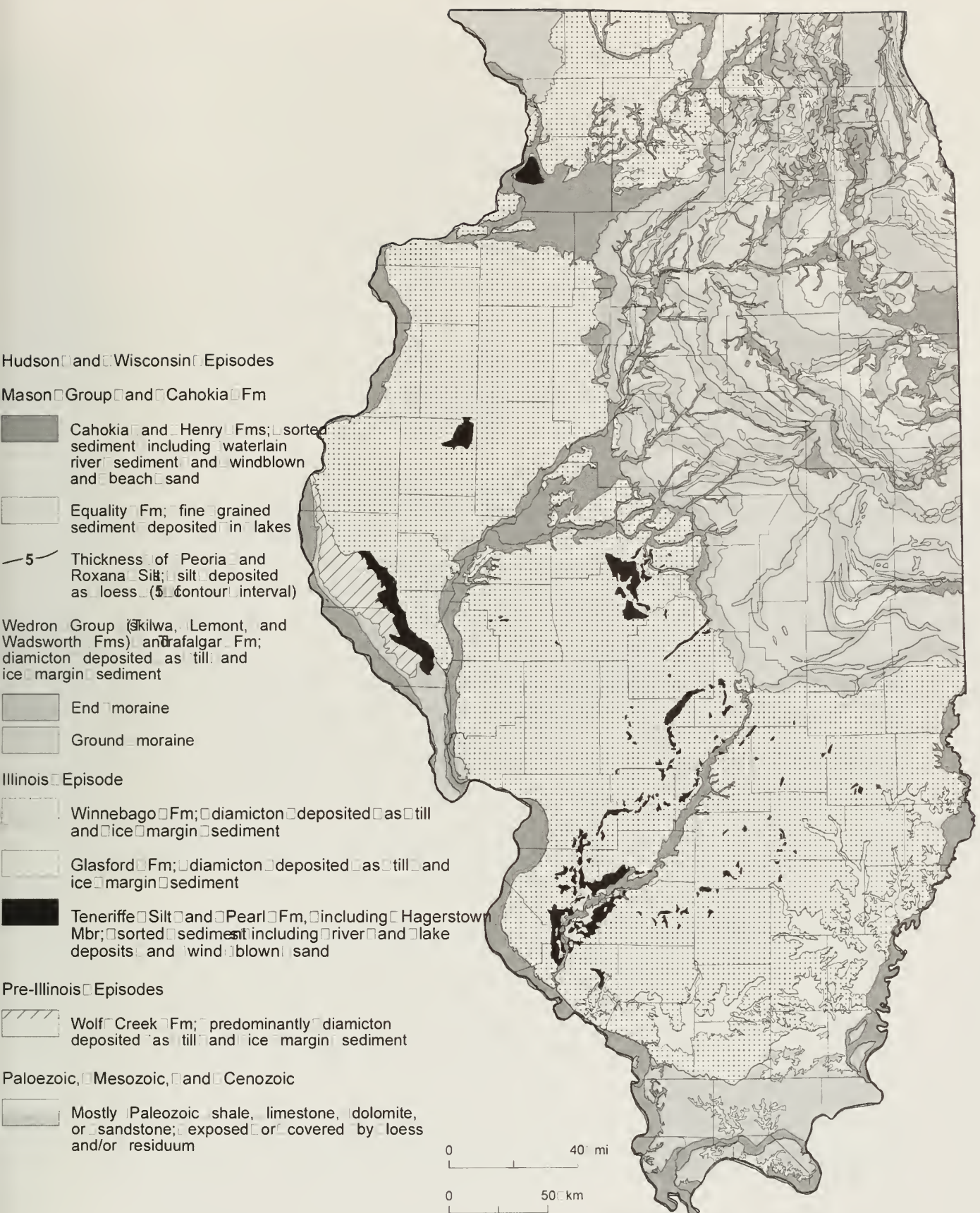


Figure 12 Generalized map of glacial deposits in Illinois (modified from Willman and Frye 1970).

Illinois Episode; Hansel and Johnson 1996), they are called simply pre-Illinois glacial episodes (see number 1 on fig. 13). The pre-Illinois glacial episodes ended about 425,000 years ago.

A long interglacial episode, called the Yarmouth (see number 2 on fig. 13), followed the last of the pre-Illinois glacial advances. The Yarmouth interglacial episode is estimated to have lasted approximately 125,000 years, and deep soil formation took place during that long interval (Yarmouth Geosol). On the parts of the landscape that were generally poorly drained, fine *silts* and clays slowly accumulated (accreted) in shallow, wet depressions and formed what are called accretion gleys, which are characterized by dark gray to black, massive, and dense clay deposits.

The Illinois Episode of glaciation began approximately 300,000 years ago and lasted for about 175,000 years (see number 3 on fig. 13). During this interval, ice advanced three times out of the northeastern center of accumulation. During the Illinois Episode, the continental glaciers in North America reached their southernmost position, approximately 25 miles southwest of Harrisburg in the northern part of Johnson County (fig. 12). Locally, the glacier stopped 5 miles north of Harrisburg. During the first of these advances, ice of this episode reached westward across Illinois and into Iowa.

Another long interglacial episode, called the Sangamon (number 4 on fig. 13), followed the Illinois Episode and lasted about 50,000 years. Although shorter than the Yarmouth interglacial episode, this interval's length was sufficient for another major soil, the Sangamon Geosol, to develop. The Sangamon Geosol exhibits both well-drained and poorly drained soil profiles. Although accretion gleys in the Sangamon are not as widespread as they are in the Yarmouth Geosol, they are fairly common and are easily identified by the same characteristics as the Yarmouth accretion gleys.

About 75,000 years ago, the Wisconsin Episode of glaciation began. Ice from the early and middle parts of this episode (number 5 on fig. 13) did not reach into Illinois. Although late Wisconsin Episode ice (number 6 on fig. 13) did advance across northeastern Illinois beginning about 25,000 years ago, it did not reach southern or western Illinois (fig. 12). The effects of the late Wisconsin glaciation in the field trip area are represented by backwater glacial lake sediments of the Equality Formation (see fig. 12) and the windblown silts (*loess*—pronounced “luss”) that blanket the landscape and compose the parent materials for modern soils. The maximum thickness of the ice in the late Wisconsin Episode glaciers was about 2,000 feet in the Lake Michigan Basin, but only about 700 feet over most of the Illinois land surface (Clark et al. 1988). The last of these glaciers melted from northeastern Illinois about 13,500 years B.P. (before the present).

Wisconsin Episode moraines were deposited in Illinois from approximately 25,000 to 13,500 years ago. Although Illinois Episode glaciers probably built morainic ridges similar to those of the later Wisconsin Episode glaciers, the Illinois Episode moraines apparently were not as numerous and have been exposed to weathering and erosion for approximately 280,000 years longer than their younger Wisconsin Episode counterparts. For these reasons, Illinois Episode glacial features generally are not as conspicuous as the younger Wisconsin Episode features.

In general, glacial deposits consist primarily of (1) *till*—pebbly clay, silt, and sand, deposited directly from melting glaciers; (2) *outwash*—mostly sand and gravel, deposited by the rapidly flowing meltwater rivers; (3) *lacustrine deposits*—silt and clay that settled out in quiet-water lakes and ponds; and (4) *loess*—windblown sand and silt.

Within the vicinity of the field trip area, north of Harrisburg, glacial drift generally ranges from a few feet to somewhat more than 25 feet thick. Glacial deposits slightly more than 50 feet thick can be found along the preglacial *bedrock valley* of the Saline River and its tributaries. However,

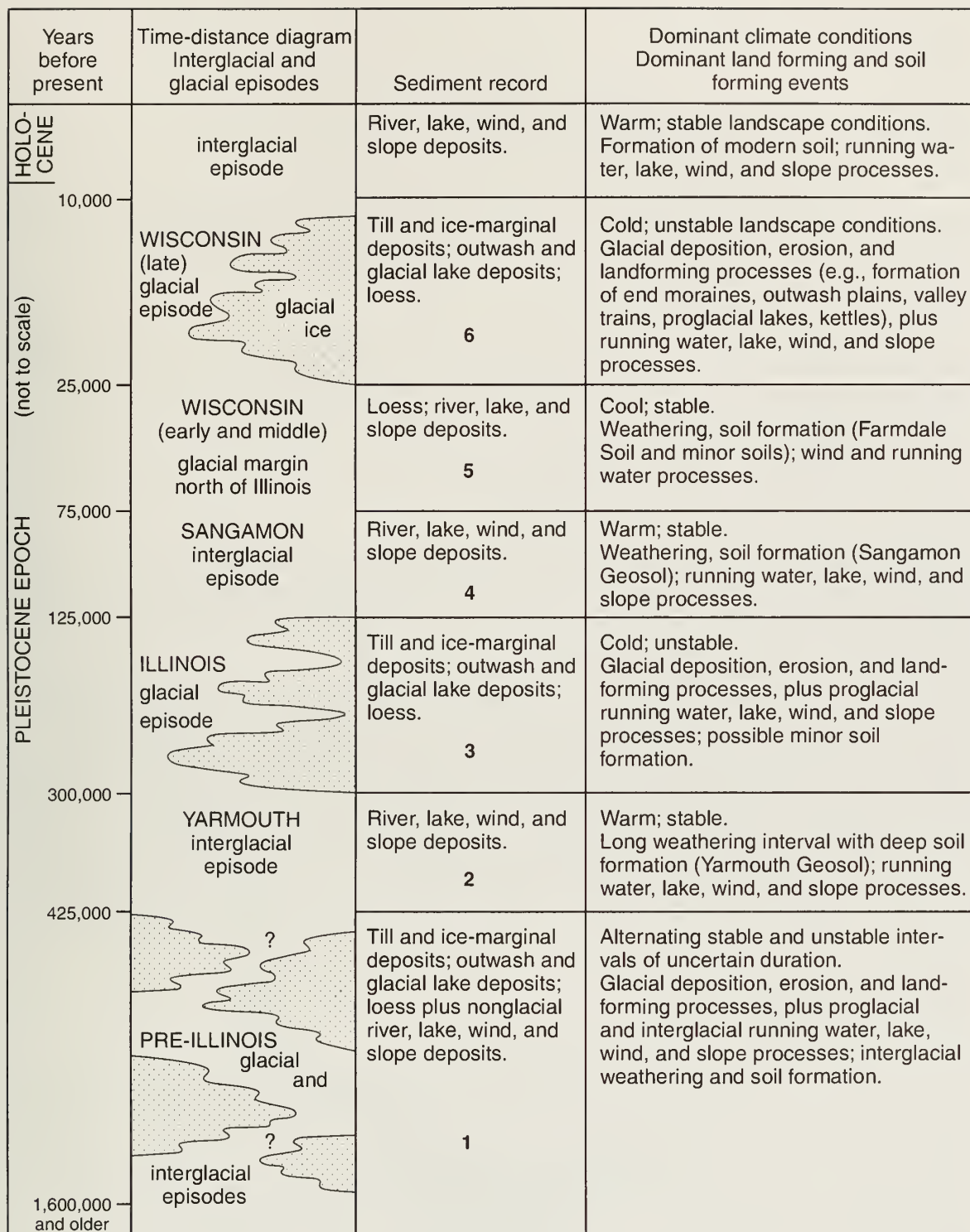


Figure 13 Timetable illustrating the glacial and interglacial events, sediment record, and dominant climate conditions of the Ice Age in Illinois (modified from Killey 1998).

in several localities, bedrock is exposed, and the glacial deposits have been completely removed by erosion.

The sediments that formed the flat topography immediately north of the Shawnee Hills, from Harrisburg east to the Ohio River, are lacustrine deposits of the Equality Formation (fig. 12). These flatlands of the Saline River Valley represent the bottom of an old glacial lake (Lake Saline) that once covered this area. In this vicinity, the sediments that accumulated in the lake consist of more than 100 feet of clay, silt, sand, and gravel. Some of these lake sediments probably date from the Illinois glaciation about 200,000 years ago, but most of the sediments were deposited during the melting of the late Wisconsin glaciers from about 20,000 to 10,000 years ago.

Flooding of the lowland areas in southern Illinois and adjacent parts of Indiana and Kentucky was especially extensive during the melting of the large ice mass at the end of the Wisconsin glaciation. Vast amounts of meltwater poured from the ice front and caused extensive flooding in the Mississippi, Illinois, Wabash, and Ohio River valleys. In this area, a great lake was formed as these floodwaters backed up the Saline River Valley and its tributaries. Low areas in the Eagle Valley Syncline to the south were also flooded. At its greatest extent, this lake probably reached an elevation of about 400 feet above sea level.

The former lake bed in the Saline River valley still floods from time to time when the Ohio River rises high enough, and the Pleistocene lake sediments are veneered with sediment of Recent Epoch. The flood of 1937 is thought to have formed a lake approximately the size of the Wisconsin glacial Lake Saline that existed 13,000 years ago.

The loess that mantles the bedrock and glacial drift throughout the field trip area was laid down by the wind during all of the glacial episodes, from the earliest pre-Illinois glacial episode (approximately 1.6 million years ago) to the last glacial episode, the Wisconsin Episode. This yellowish brown silt occurs on the uplands and mantles the glacial drift throughout the field trip area. The loess is generally between 4 and 8 feet thick, but erosion has completely removed it in scattered areas in the Shawnee Hills area of the field trip. The thickness of the loess generally increases to the west and east toward the Mississippi and Illinois Rivers. The loess, which covers most of Illinois, is up to 15 feet thick along the Illinois River valley and is more than 50 feet thick along the east edge of the Mississippi River valley.

GEOMORPHOLOGY

Physiography

Physiography is a general term used for describing landforms; a physiographic province is a region in which the relief or landforms differ markedly from those in adjacent regions. The field trip area is located in two distinctly different physiographic provinces. North of the *escarpment* formed by the uplifted Pennsylvanian rocks of the Shawnee Hills is the Mt. Vernon Hill Country—a physiographic division within the Till Plains Section of the Central Lowland Physiographic Province (fig. 14). The Till Plains Section is divided into seven distinct divisions in Illinois. The present gross topographic features of the Till Plains Section are largely determined by the underlying preglacial topography. The Central Lowland Province is bordered on the south and west by uplands containing extensive remnants of an older erosional surface. Prior to glaciation, the lowland surface was incised by a drainage system consisting of many deep bedrock valleys. The area south of the Pennsylvanian Escarpment is defined as the Shawnee Hills Section of the Interior Low Plateaus Province (fig. 14).

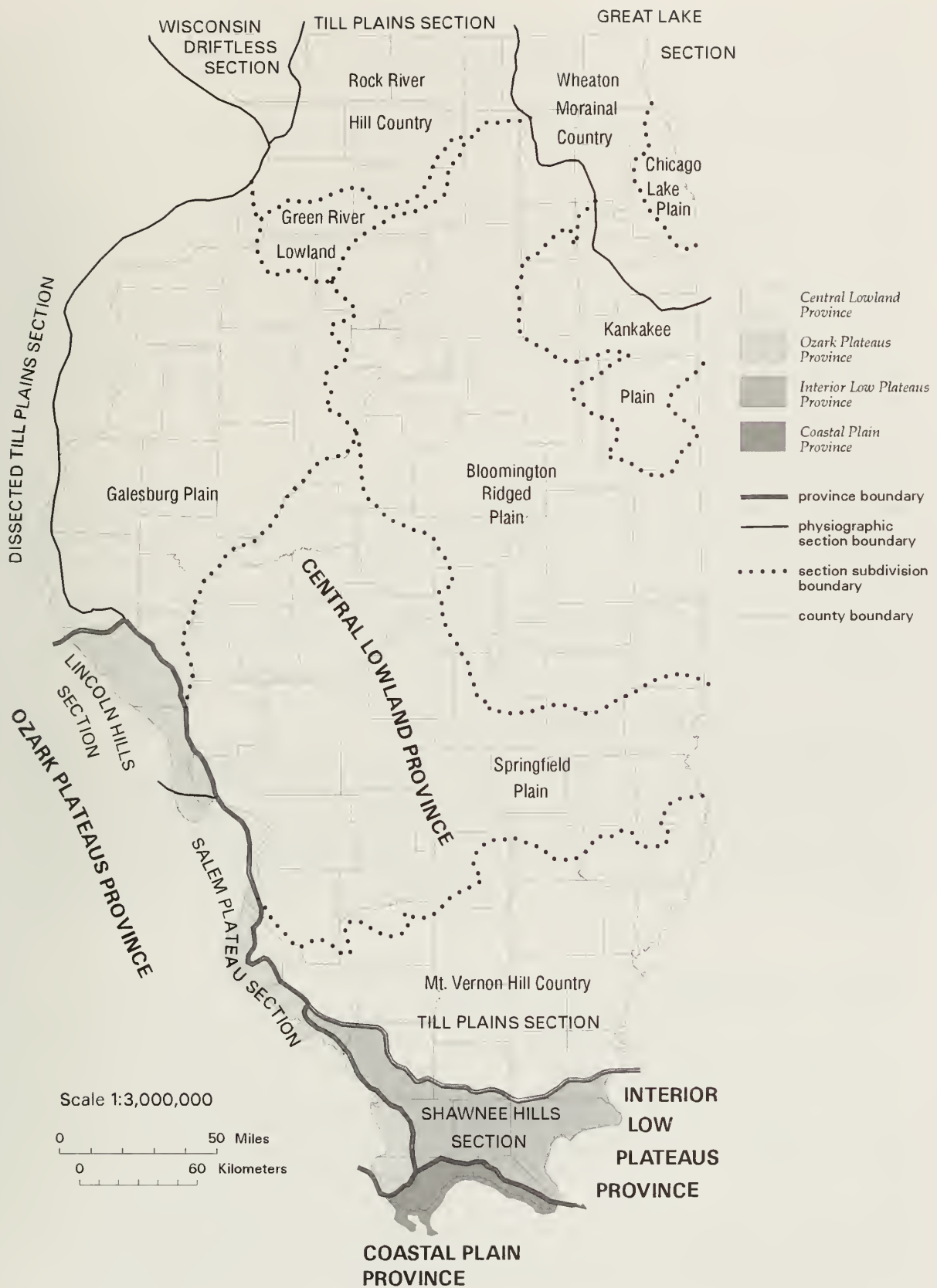


Figure 14 Physiographic divisions of Illinois (modified from Leighton et al. 1948).

Mt. Vernon Hill Country comprises the southern portion of the area covered by the drift sheet left by the Illinois Glacial Episode and the area covered by the Wisconsin Glacial Episode deposits of the Equality Formation. The Mt. Vernon Hill Country is characterized by mature topography of low relief with restricted upland prairies and broad alluviated valleys along the larger streams. The covering of glacial sediments is thin, and glacial landforms are essentially absent. The present land surface is primarily a bedrock surface of low relief only slightly modified and subdued by the mantle of glacially deposited material. According to Leighton et al. (1948), an extensive lowland called the “central Illinois peneplain” (a low, nearly featureless, gently undulating land surface) was eroded prior to glaciation into the relatively weak rocks of Pennsylvanian age east and south of the present-day Illinois River. Apparently, just before the advent of glaciation, an extensive system of bedrock valleys was deeply entrenched below the central lowland surface level. As glaciation began, streams probably changed from erosion to aggradation; that is, their channels began to build up and fill in with sediment because the streams did not have sufficient volumes of water to carry and move the increased volumes of sediment. To date, no evidence indicates that the early fills in these preglacial valleys were ever completely flushed out of their channels by succeeding deglaciation meltwater torrents.

Shawnee Hills Section includes a complex dissected upland underlain by Mississippian and Pennsylvanian bedrock of varied lithology (see figs. 7, 12, and 14). It is located along the southern rim of the Illinois Basin, with a *cuesta* (a ridge with a gentle slope on one side and a steep slope on the other) of lower Pennsylvanian rocks generally forming its northern margin and its southern part comprising a dissected plateau underlain largely by Mississippian rocks. In the Shawnee Hills Section, erosional remnants of a preglacial land surface called the Ozark Plateaus are extensive along the Pennsylvanian escarpment. Locally higher summits and some lower surfaces on Mississippian rocks indicate a complex erosional history that continued during all of the glacial episodes.

NATURAL DIVISIONS AND GEOLOGY

Glacial history has played an important role in shaping Illinois topography by eroding the preglacial landscape and depositing glacial sediments. Topography influences the diversity of plants and animals (biota) of Illinois by strongly influencing the diversity of habitats. Geological processes form, shape, and create the topography on all of the Earth’s surface. Specifically, geological processes not only determine the composition of the parent material of soils, but also the formation of soils through the weathering of parent materials. Thus, the geology of a region is the foundation of its habitats.

Natural Divisions

The state has been divided into 14 different natural divisions. These divisions are distinguished by differences in topography, glacial history, bedrock geology, soils, aquatic habitats, and distribution of native plants and animals (flora and fauna). A strong relationship exists between the physiographic divisions of Illinois and the natural divisions of Illinois because the geologic factors used to determine the physiographic divisions were important elements used to define the boundaries of the natural divisions. Of the 14 natural divisions in Illinois, the field trip area is located along the boundary between the Southern Till Plain Division (northern part of the field trip area) and the Shawnee Hills Division (southern part of the field trip area). The geographic area of the Southern Till Plain Division is roughly equivalent to the Mt. Vernon Hill Country physiographic division, and the Shawnee Hills Division is equivalent to the Shawnee Hills Section. The following descriptions of the natural divisions are modified from Schwegman (1973).

The Southern Till Plain Division encompasses most of the area of dissected Illinois Glacial Episode till plain south of the Shelbyville Moraine (Wisconsin Glacial Episode terminal moraine) and the Sangamon River and Macoupin Creek watersheds. Both forest and prairie were present at the time of settlement. The soils are relatively poor because of their high clay content and the occurrence of a claypan subsoil in many places. Post oak flatwood forest is characteristic of the division. The two sections are distinguished because of topographic differences.

- **Bedrock** The bedrock of the Southern Till Plain Division consists of sandstone, limestone, coal, and shale, which commonly crop out in the eastern and southeastern parts of the division. Bedrock lies near the surface in the Mt. Vernon Hill Country Section.
- **Glacial History** The Illinoian stage of Pleistocene glaciation reached the southernmost limit of continental glaciation in North America just beyond the limits of this division. The Southern Till Plain Division is entirely covered by Illinoian till. Glacial landforms are common only in the northwestern part of the division.
- **Topography** The glacial till of the Southern Till Plain Division becomes thinner from north to south. The bedrock of the Mt. Vernon Hill Country Section is near the surface, accounting for the hilly and rolling topography. The Effingham Plain Section is a nearly level to dissected till plain. There are broad floodplains along the major streams, and there are ravines in the bluffs along the stream valleys.
- **Soils** The soils on the uplands are light colored and strongly developed, with poor internal drainage. They have developed from thin loess and till under both forest and prairie vegetation. Fragipan and claypan layers are characteristic of the upland soils. Some of the prairie soils have a high sodium content and are known locally as “alkaline slicks.”

The Shawnee Hills Division extends across the southern tip of Illinois from Fountain Bluff on the Mississippi River to the Shawneetown Hills near the mouth of the Wabash River. This unglaciated hill country is characterized by a high east-west escarpment of sandstone cliffs forming the Greater Shawnee Hills and a series of lower hills underlain by limestone and sandstone known as the Lesser Shawnee Hills. Originally this division was mostly forested, and considerable forest remains to the present time. A number of distinctive plant species are restricted to this division of Illinois.

- **Bedrock** The Greater Shawnee Hills form a band along the northern edge of the division and consist of massive Pennsylvanian sandstone strata that dip northward toward the Illinois Basin. The Greater Shawnee Hills are 10 miles wide on average and border the Lesser Shawnee Hills to the south. The Lesser Shawnee Hills are underlain by Mississippian limestone and sandstone, and sinkholes and caves are locally common features. Mineralized faults containing fluor spar and zinc, silver, and other metals exist in the eastern part of the Shawnee Hills Division. Iron deposits are found in Hardin County. There is a dome containing an igneous rock core in western Hardin County, and outcrops of igneous rock occur in the Lesser Shawnee Hills Section.
- **Topography** The topography of the Shawnee Hills Division is very rugged, with many bluffs and ravines. The north slopes of the Greater Shawnee Hills Section are relatively gentle, but the south slopes consist of many escarpments, cliffs, and overhanging bluffs. Streams have eroded canyons in the sandstone. The Lesser Shawnee Hills are about 200 feet lower, on average, than the Greater Shawnee Hills. The Lesser Shawnee Hills have local areas of sinkhole topography.

- **Soils** The soils are derived mainly from loess. Narrow bands of moderately developed deep loess soils occur along the Mississippi River in Jackson County and along the Ohio River in eastern Hardin County; however, most of the soils are derived from thinner loess and are strongly developed. Claypan and fragipan layers are frequent.

NATURAL RESOURCES

Mineral Production

The total value of all minerals extracted, processed, and manufactured in Illinois during 1995 was \$2,202,300,000. Minerals extracted accounted for 87.6% of this total. Coal continued to be the leading commodity, followed by industrial and construction materials, oil, metals, peat, and gemstones. Illinois ranked 5th among coal-producing states, 13th among the 31 oil-producing states, and 16th among the 50 states in total production of nonfuel minerals. Illinois continues to lead all other states in production of industrial sand and tripoli.

Fluorspar

Fluorspar is the state mineral of Illinois, and Illinois was long the principal fluorspar producer in the country. The first recorded fluorspar mining in Illinois was in 1842 when a small operation was started in Hardin County in southern Illinois. Production continued to be centered there. Production rose from 104.7 thousand tons in 1940 to 198.7 thousand tons in 1943. In 1940, about 48% of the nation's fluorspar demand was met by the shipments from Illinois. The state's share increased to 51% in 1943, but declined to zero thereafter. In the early days, fluorspar output came from numerous mines ranging from those producing only a few hundred tons per year to those producing tens of thousands of tons annually. The extremely competitive conditions and high production costs forced most of the producers out of business over time.

By 1995, Ozark-Mahoning Co., a subsidiary of the Pennsylvania-based Elf Atochem North America Inc., was the nation's only fluorspar producer. In 1995, total fluorspar shipments from this company were 48,000 tons, which accounted for 8.5% of the nation's fluorspar requirements. On January 31, 1996, Elf Atochem North America closed its two mines and a flotation plant in Hardin County, because of depletion of reserves at active mines and competition from China. Ozark-Mahoning, which had been in operation since 1938, was the last active fluorspar mining company in the country. With the closure of Ozark-Mahoning's operations, the United States ended 158 years of fluorspar mining. Hastie Mining and Trucking Co., a local quarry company, leased Ozark-Mahoning's mineral drying and bagging facilities to process fluorspar purchased from the national defense stockpile. The company will probably service some of the former customers of Ozark-Mahoning by making a calcined product.

Barite, copper, lead, silver, and zinc (sphalerite) concentrates were recovered as co-products of fluorspar processing in Illinois. Fluosilicic acid, a by-product, was also recovered from fluorspar processing. It was used primarily in the aluminum industry for making aluminum fluoride and in water fluoridation, either directly or after processing to sodium silicofluoride.

Acid-grade fluorspar, containing greater than 97% calcium fluoride, is used primarily as a feed-stock in the manufacture of hydrogen fluoride and to produce aluminum fluoride. Ceramic-grade fluorspar (85% to 95% CaF_2) is used for the production of glass and enamel, to make welding rod coatings, and as a *flux* (a substance used to remove impurities from steel) in the steel industry. Metallurgical-grade fluorspar (65% to 85% CaF_2) is used primarily as a fluxing agent in the steel industry.

The reported domestic consumption by the hydrogen fluoride industry increased by nearly 4% in 1996. The reported consumption by the non-hydrogen fluoride industries decreased by 19% from its level in 1995 (USGS, *Mineral Industry Surveys, Fluorspar 1997 Annual Review*). In the ceramic industry, fluorspar was used as a flux and as an opacifier in the production of flint glass, white or opal glass, and enamels.

Groundwater

Groundwater is a resource frequently overlooked in assessments of an area's natural resource potential. The availability of this resource is essential for orderly economic and community development. More than 35% of the state's 11.5 million citizens and 97% of those who live in rural areas depend on groundwater for their water supply. Groundwater is derived from underground formations called *aquifers*. The water-yielding capacity of an aquifer can only be evaluated by constructing wells into it. After construction, the wells are pumped to determine the quality and quantity of groundwater available for use.

GUIDE TO THE ROUTE

We will start the trip at the Shawnee National Forest Headquarters in Harrisburg, Illinois (SE, SW, NW, Sec. 22, T9S, R6E, 3rd P.M., Harrisburg 7.5-minute Quadrangle, Saline County). Mileage will start at the exit of the parking lot.

You must travel in the caravan. Please drive with headlights on while in the caravan. Drive safely but stay as close as you can to the car in front of you. Please obey all traffic signs. If the road crossing is protected by an Illinois State Geological Survey (ISGS) vehicle with flashing lights and flags, please obey the signals of the ISGS staff directing traffic. When we stop, park as close as possible to the car in front of you and turn off your lights.

Respect private property. Some stops on the field trip are on private property. The owners have graciously given us permission to visit on the day of the field trip only. Please conduct yourselves as guests and obey all instructions from the trip leaders. So that we may be welcome to return on future field trips, follow these simple rules of courtesy:

- Do not litter the area.
- Do not climb on fences.
- Leave all gates as you found them.
- Treat *public* property as if you were the owner—which you are!
- Stay off of all mining equipment.
- Parents must closely supervise their children at all times.

When using this booklet for another field trip with your students, a youth group, or family, remember that *you must get permission from property owners or their agents before entering private property*. No trespassing, please.

Five U.S. Geological Survey (USGS) 7.5-minute quadrangle maps (Equality, Harrisburg, Herod, Karbers Ridge, and Rudement) provide coverage for this field trip area.

Miles to next <u>point</u>	Miles from <u>start</u>
----------------------------------	-------------------------------

0.0	0.0	Set your odometers to 0.0 at the exit of the parking lot. Exit parking lot and TURN RIGHT onto Illinois Route 145/34.
0.4	0.4	Road begins slight ascent as you enter the community of Pankeyville.

This rise in elevation coincides with one of the several small bedrock hills that occur south of Harrisburg. These bedrock hills are part of the Carbondale Formation of the Pennsylvanian age sediments. A number of abandoned surface coal mines are located along the southern flanks of most of these bed-

rock highs. From 1947 to 1949, the Bankston Creek Colliery Company operated a strip mine immediately south of Pankeyville. The company was mining the Springfield (No. 5) Coal, which is locally known as the Harrisburg coal seam. In addition to the surface mines, the Springfield/Harrisburg seam has been extensively underground-mined in a large area that completely surrounds Harrisburg.

- | | | |
|-----|------|--|
| 0.8 | 1.2 | Road begins descent off of the bedrock high on south edge of the community of Pankeyville. The view of the hills to the southeast and straight ahead is the Pennsylvanian Escarpment, which forms the northern limit of the Shawnee Hills. |
| 0.7 | 1.9 | Note the flat topography in this area.

The flatlands of the Saline River valley represent the bottom of an old glacial slack-water lake (Lake Saline) that once covered this area during the Wisconsin Glacial Episode. In this vicinity, the sediments that accumulated in the lake consist of clay, silt, sand, and some gravel. These deposits are part of the Carmi Member of the Equality Formation. |
| 2.5 | 4.4 | Cross the Saline River. Notice the straight channelized section of the Saline River to your left. |
| 0.2 | 4.6 | Cross the old abandoned course of the Saline River. Notice the meanders to your left. |
| 0.2 | 4.8 | Entering the community of Mitchellsville. |
| 0.7 | 5.5 | Prepare to turn left and follow Illinois Route 34. Pass the sign indicating Garden of the Gods 16 miles to the left and Lake Glendale 20 miles straight ahead. |
| 0.1 | 5.6 | T-intersection from the left (Illinois Route 34/285N and Illinois Route 145/950E). TURN LEFT. We are following Shawnee Hills and the Ohio motor route along this part of the field trip route. |
| 0.8 | 6.4 | Notice the nice view of the Shawnee Hills directly ahead of us. |
| 0.1 | 6.5 | Cross Blackman Creek |
| 1.2 | 7.7 | Cross Spring Valley Creek and enter the community of Rudement. |
| 0.7 | 8.4 | Cross unnamed creek. T-intersection from the left, just past the bridge (DeNeal Road/1210E and Illinois Route 34/250N). CONTINUE AHEAD. The road to your left leads to Old Stoneface. Notice that the road begins to rise in elevation. You are leaving the flat topography of the Equality Formation and entering into the northern boundary of the Pennsylvanian Escarpment. |
| 1.8 | 10.2 | Road follows valley cut by Gibbons Creek. |

1.0	11.2	Enter Pope County.
1.4	12.6	Enter the community of Herod.
0.1	12.7	Outcrop of cross-bedded sandstone, Pennsylvanian, Battery Rock Member of the Caseyville Formation on the right with a small cave “rock shelter” at the base of the sandstone bluff.
0.2	12.9	T-intersection from the right. CONTINUE AHEAD. The road to the right leads to Williams Hill with an elevation of 1,064 feet above sea level.
0.1	13.0	Cross Gibbons Creek and a T-intersection from the left, just past the bridge. CONTINUE AHEAD. NOTE: The River to River Trail crosses the road at this location.
1.6	14.6	Enter Hardin County.
0.1	14.7	Cross Rose Creek and prepare to turn left onto Karbers Ridge Road.
0.2	14.9	T-intersection from the left (Illinois Route 34/025E and Karbers Ridge Road/1065N). TURN LEFT onto Karbers Ridge Road. CAUTION: Large coal-hauling trucks use this road.
0.9	15.8	Great view of the Shawnee Hills to your left. Notice the large sandstone outcrops, along the top of the hills, which form the bluffs at the Garden of the Gods Recreation Area.
1.8	17.6	Prepare to turn left.
1.9	17.7	Crossroad intersection (Garden of the Gods Road/250E and Karbers Ridge Road/1180N). TURN LEFT.
0.6	18.3	Cross Rose Creek.
0.5	18.8	Outcrop on the right side of the road. Pennsylvanian age Lower Caseyville Formation, Lusk Creek Member shales and siltstones that grade upward into the Battery Rock Sandstone can be seen.
0.1	18.9	Outcrop of Battery Rock Sandstone on the right side of the road. Prepare to turn left.
0.1	19.0	T-intersection from the left (Garden of the Gods Road). TURN LEFT. Entrance to Garden of the Gods Recreation Area.
0.8	19.8	Battery Rock Sandstone outcrop on the right side.
0.05	19.85	Small pull-over parking lot on the left. A rock shelter cave is in the Pounds Sandstone bluff on the right.

0.05	19.9	Backpackers' parking lot on the left. CONTINUE AHEAD. Pass the sign indicating observation trail; picnic and camping straight ahead.
0.2	20.1	River to River Trail crosses the road.
0.2	20.3	Y-intersection (Picnic Road/050N and Garden of the Gods Road/1750E). BEAR LEFT. Sign indicating observation trail is to the left, and picnic ground and campground are to the right. Enter the lower portion of the parking lot and park your vehicles.

STOP 1: Garden of the Gods Recreation Area, Shawnee National Forest (SW, NW, SE, Sec. 36, T10S, R7E, 3rd P.M., Herod 7.5-minute Quadrangle, Saline County). On the day of the field trip, assemble near the trail head sign, which is near the middle of the upper parking lot.

0.0	20.3	Leave Stop 1 and retrace your route back to the Y-intersection.
0.2	20.5	YIELD: Y-intersection (Picnic Road/050N and Garden of the Gods Road/1750E). TURN RIGHT onto the Garden of the Gods Road.
0.3	20.8	Pass backpackers' parking area on the right. CONTINUE AHEAD.
1.0	21.8	STOP at T-intersection (Garden of the Gods Road and County Highways 17 and 10). RESET ODOMETER.
0.0	0.0	TURN RIGHT. Heading toward Karbers Ridge Road. CAUTION: Fast-moving traffic from the left. Road is used by large coal haulage trucks. NOTE: County Hwy. 17 is in Gallatin County to the left, and County Hwy. 10 is in Hardin County to the right.
1.2	1.2	Prepare to stop.
0.1	1.3	STOP. Crossroad intersection (Karbers Ridge Road/1180N and Garden of the Gods Road/250E). TURN LEFT.
0.5	1.8	T-intersection from the right. CONTINUE AHEAD. The road to the right leads to Hicks Dome.
1.0	2.8	T-intersection from the right (400E and Karbers Ridge Road/1175N). CONTINUE AHEAD. The road to the right leads to Iron Furnace (seven miles).
0.2	3.0	T-intersection from the left (425E). CONTINUE AHEAD. The road to the left leads to High Knob, 929 feet above sea level (two miles).
0.5	3.5	T-intersection from the right (475E). CONTINUE AHEAD.
0.3	3.8	Karbers Ridge School on the left. CONTINUE AHEAD.

0.5	4.3	Prepare to make a right turn.
0.1	4.4	T-intersection from the right (Cadiz Road/550E and Karbers Ridge Road/1150N). TURN RIGHT.
0.4	4.8	Cross Big Creek.
0.15	4.95	Unimproved forest road on the right (Forest Road 1793). Pull over to the far right side of the road and park.

STOP 2: Lee Mine, an abandoned fluorspar mine, Shawnee National Forest (NW, NW, NW, Sec. 14, T11S, R8E, 3rd P.M., Karbers Ridge 7.5-minute Quadrangle, Hardin County). On the day of the field trip, we will hike along the forest road, approximately 3,000 feet, to the Lee Mine.

0.0	4.95	Leave STOP 2. CONTINUE AHEAD.
0.45	5.4	Pass Waters Cemetery on the right.
0.2	5.6	Pass Philadelphia Church of Christ on the right.
0.2	5.8	T-intersection from the left (Sparks Hill Road/690E and Cadiz Road/1125N). TURN LEFT. After making the turn, Matthews Cemetery is on the left. CAUTION: This is a narrow gravel road.
0.5	6.3	CAUTION: Ford crossing of Big Creek.
0.3	6.6	Enter the abandoned community of Sparks Hill.
0.3	6.9	T-intersection from the right. CONTINUE AHEAD. Road leads to McPherson-Love Cemetery.
0.1	7.0	STOP (one-way). T-intersection (Sparks Hill Road and Karbers Ridge Road). TURN RIGHT. CAUTION: Blind spot in the road to the left.
0.1	7.1	To the left is a water tower operated by the Hardin County Water Company.
0.7	7.8	Prepare to turn left. Leave Hardin County and enter Gallatin County. NOTE: Karbers Ridge Road is called Pounds Hollow Road in Gallatin County.
0.1	7.9	T-intersection from the left (Forest Road 121). TURN LEFT. Entrance to Rim Rock Recreation Area and the Pounds Escarpment. Hill Cemetery is opposite the entrance.
0.1	8.0	Enter the parking loop of Rim Rock Recreation Area and park your vehicles. This is Stop 3 and lunch. We will eat lunch in the Indian Wall picnic ground.

STOP 3: LUNCH Rim Rock Recreation Area and the Pounds Escarpment, Shawnee National Forest (NE, SW, SW, Sec. 36, T10S, R8E, 3rd P.M., Karbers Ridge 7.5-minute Quadrangle, Gallatin County)

0.0	8.0	Leave Stop 3 and retrace your route back to Pounds Hollow/Karbers Ridge Road.
0.3	8.3	STOP. T-intersection (Pounds Hollow Road). TURN RIGHT. NOTE: Pounds Hollow is two miles to your left.
0.6	8.9	Pass Hardin County Water Company tower on the right.
0.8	9.7	Pass Russell Cemetery on the right.
0.9	10.6	T-intersection from the left (Cadiz Road/550 E and Karbers Ridge Road/1150N). CONTINUE AHEAD.
0.6	11.2	Pass Karbers Ridge School on the right.
0.2	11.4	T-intersection from the left (475E). CONTINUE AHEAD. NOTE: This road will take you to Elizabethtown, where the Shawnee National Forest Elizabethtown Ranger Station is located.
0.5	11.9	T-intersection from the right (425E). CONTINUE AHEAD. Road leads to High Knob.
0.3	12.2	T-intersection from the left (400E). CONTINUE AHEAD. Road leads to the Iron Furnace (seven miles).
0.5	12.7	CAUTION: large trucks possibly entering the road from the right.
0.5	13.2	T-intersection from the left (300E). CONTINUE AHEAD.
0.4	13.6	Prepare to turn right.
0.1	13.7	Crossroad intersection (Garden of the Gods Road/250E and Karbers Ridge Road/1180N). TURN RIGHT.
1.4	15.1	Entrance to the Garden of the Gods Recreation Area. CONTINUE AHEAD.
0.1	15.2	CAUTION: Just past the Garden of the Gods entrance the road winds like a snake slithering through the Shawnee Hills.
0.7	15.9	CAUTION: Steep grade ahead.
0.9	16.8	River to River Trail crosses the road.

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| 0.4 | 17.2 | Entering very steep grade in the road. You are traversing down the southern flank of the Eagle Valley Syncline. NOTE: The road is now called Forest Road, also locally known as the County Line Road. Saline County is to the left, and Gallatin County is to the right. |
| 0.7 | 17.9 | Cross Little Eagle Creek at the base of the bluffs. |
| 0.4 | 18.3 | STOP (four-way). Crossroad intersection (Eagle Creek Road/275N and Forest Road/1800E). CONTINUE AHEAD. The right half of this intersection is marked as Barnett Cemetery Road/4750N and Forest Road/1E. The numerous names for this intersection are because Gallatin County is to the right and Saline County is to the left. |

STOP 4A (Optional): Jader Coal Company is to the left. Depending upon the current mining conditions and the location of the active surface mine pits, we will make a decision on the day of the field trip to visit either Jader Coal Company or Black Beauty Coal Company.

- | | | |
|-----|------|---|
| 0.1 | 18.4 | Just north of the intersection is an outcrop of Pennsylvanian age sandstones of the Carbondale Formation on the right side of the road. These rocks dip 11E to the north and form the southern edge of the Eagle Valley Syncline. |
| 0.4 | 18.8 | Pass a reclamation project of the Department of Natural Resources on the left side of the road. This area has been extensively surface- and underground-mined for coal. |
| 0.6 | 19.4 | Cross Eagle Creek. Notice the outcrop of the Herrin (No.6) Coal Member of the Carbondale Formation on the right side of the road just past the bridge. |
| 0.4 | 19.8 | Outcrop of Pennsylvanian age Gimlett Sandstone Member of the Shelburn Formation on the left side of the road. |
| 0.8 | 20.6 | T-intersection from the right (Kedron Road/700N). CONTINUE AHEAD. |

STOP 4B (Optional): Black Beauty Coal Company Wildcat Mine operations, is to the right. Depending upon the current mining conditions and the location of the active surface mine pits, we will make a decision on the day of the field trip to visit either Jader Coal Company or Black Beauty Coal Company.

- | | | |
|-----|------|--|
| 1.0 | 21.6 | Cross Sandy Branch Creek. |
| 0.3 | 21.9 | Cross Horseshoe Creek. T-intersection to the left, immediately past the bridge (Eagle Creek Road/630N and Forest Road/1785E). CONTINUE AHEAD. The road to the left leads to the Saline County State Fish and Wildlife Area and Glen O. Jones Lake. |

- 0.1 22.0 Outcrop of Pennsylvanian age sandstones of the Tradewater Formation on the left side of the road. These rocks dip to the south and mark the northern edge of the Eagle Valley Syncline.
- 0.4 22.4 T-intersection from the left (Horseshoe Road/670N and Forest Road/1790E). TURN LEFT.
- 0.1 22.5 Trout Pond parking lot to the right. CONTINUE AHEAD.
- 0.1 22.6 To the left is the ghost town of Horseshoe. The following is from a historic marker at this site:

Now a ghost town, this early Saline County community was located on the Old Golconda Road, which connected Pope County communities to the Salines in the early 1800s. A U.S. Post Office operated here between 1906 and 1914.

Saline County, established in 1847 from Gallatin County, derived its name from the salt springs that abound in the area. The “Salines” is in reference to the Saline River. Several natural salt springs occur near the river in this area. One of the most famous is Negro Spring, located southeast of Equality where Illinois Route 1 crosses the Saline River. The spring is on the west side of Illinois Route 1. Follow the gravel road immediately south of the bridge over the Saline River

The United States Salines

The following is from the Illinois State Historical Society:

Two salt springs in Gallatin County produced brine for one of the earliest salt works west of the Alleghenies. One spring is just southeast of Equality and the other is a short distance west of this site. The Indians made salt here long before the first settlers appeared. In 1803 the Indians ceded their “great salt spring” to the United States by treaty. Congress refused to sell the salt lands in the public domain but it did authorize the Secretary of the Treasury to lease the lands to individuals at a royalty. The leases required the holder to produce a certain quantity of salt each year or pay a penalty.

Although the Northwest Ordinance prohibited slavery in this area, special territorial laws and constitutional provisions permitted exceptions at these salines. The lessees brought in Negroes as slaves or indentured servants and used them extensively in manufacturing salt. The census of 1820 for Gallatin County listed 239 slaves and servants.

In 1818, as part of the process of making a new state, Congress gave the salines to Illinois but forbade the sale of the land. The state continued to lease the springs and used the revenue to finance part of its operating expenses. Eventually Congress allowed the outright sale of the land. The commercial production of salt continued here until about 1837 when the low price for salt made the expense of extracting it from the brine prohibitive.

- 0.1 22.7 Pull over to the right side of the road and park your vehicles.

STOP 5: Horseshoe Upheaval (SW, NW, NE, Sec. 36, T9S, R7E, 3rd P.M., Rudement 7.5-minute Quadrangle, Saline County).

On the day of the field trip we will hike along the gravel access road, approximately 500 feet, to the north side of the Horseshoe Upheaval, which contains the best exposure. On future visits with smaller groups, you can turn right into the small parking lot.

- 0.0 22.7 Leave Stop 5. CONTINUE AHEAD.

NOTE: The road that we are traveling on parallels the Shawneetown Fault Zone, which forms the northern boundary of the Shawnee Hills immediately to the left (south). The tree line to the right marks the position of the Saline River, and the small hills in the distance on the right (north) are bedrock highs. These bedrock highs are the result of a slight upward structural flexure of the rocks between the Shawneetown Fault Zone and the Cottage Grove Fault Zone.

- 1.2 23.9 Outcrop of Mississippian age Cypress Sandstone on the right and left sides of the road.
- 0.3 24.2 Cross unnamed creek. Immediately to your right, through the dense vegetation, is the Saline River.
- 0.7 24.9 Road curves 90E to the left.
- 0.1 25.0 Road curves 90E to the right.
- 0.1 25.1 T-intersection from the left. CONTINUE AHEAD. The road to the left leads to Sulphur Springs Church, which is now abandoned. A cave in the Mississippian age Kinkaid Limestone is located in the bluff about one-half mile behind the church.
- 0.1 25.2 T-intersection from the right (Rocky Branch Road/1540E and Horseshoe Road/635N. CONTINUE AHEAD. NOTE: Rocky Branch Road crosses the Saline River and leads to Illinois Route 13.
- 0.5 25.7 Y-intersection (Horseshoe Road/600N and Stoneface Road/1515E). BEAR LEFT onto Stoneface Road/1515E. Stoneface is two miles. The road to the right leads to Illinois 34/145 ahead six miles.
- 0.3 26.0 Angled intersection from the left (Eagle Mountain Road/1510E and Stoneface Road/065N). CONTINUE AHEAD.
- 1.3 27.3 Road curves to the right.

0.1	27.4	T-intersection from the left (Stoneface Lane/1450E and Stoneface Road/450N). TURN LEFT.
0.3	27.7	Enter the loop road and parking lot. Pull over to the right side of the road and park your vehicles.

STOP 6: Old Stone Face (NW, SW, SE, Sec. 9, T10S, R7E, 3rd P.M., Rudement 7.5-minute Quadrangle, Saline County).

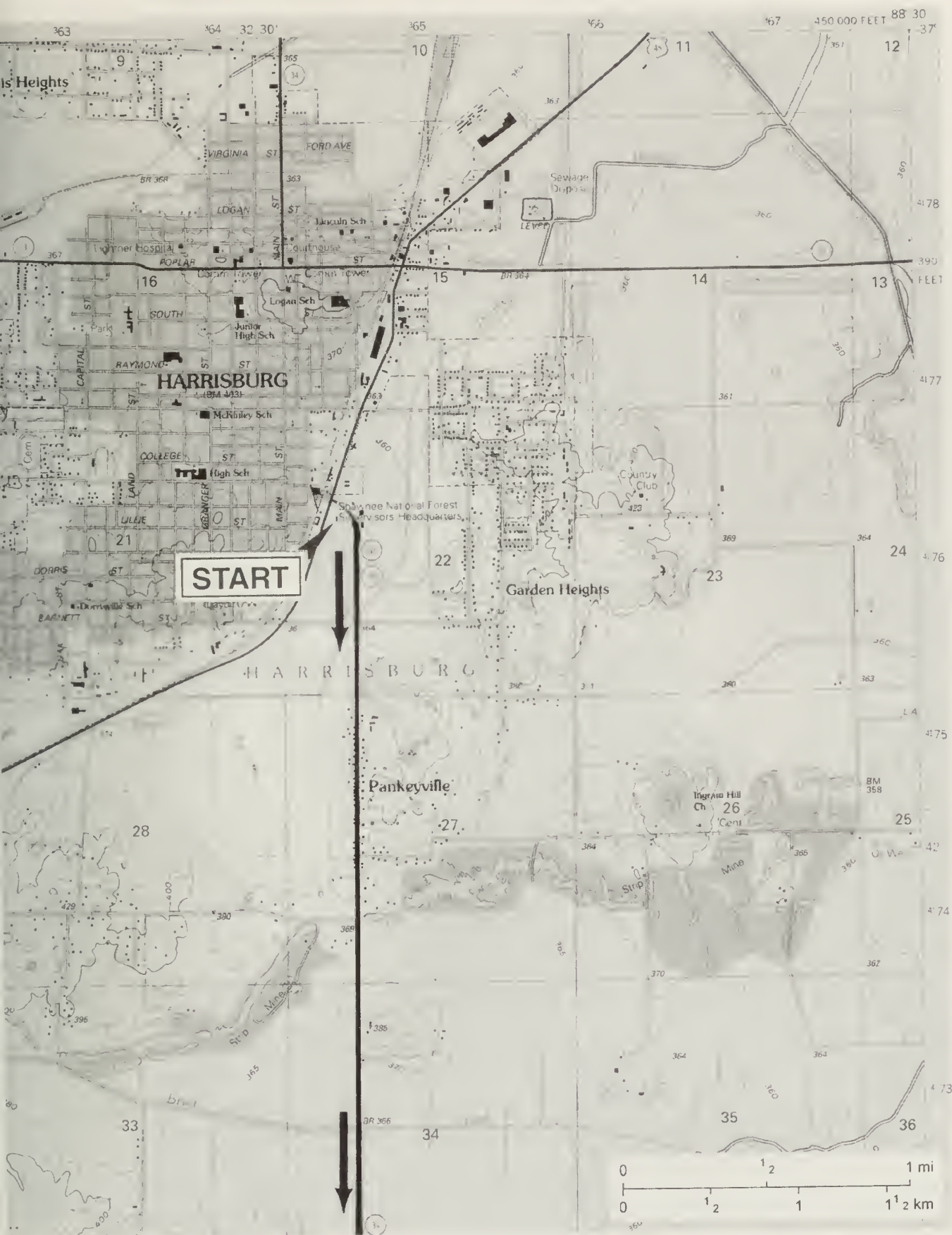
0.0	27.7	Leave Stop 6 and retrace your route back to the intersection of Stoneface Lane/1450E and Stoneface Road/450N.
0.5	28.2	STOP. T-intersection (Stoneface Lane/1450E and Stoneface Road/450N). RESET ODOMETER.
0.0	0.0	The following road log will take you from Stoneface back to Illinois Route 34. TURN LEFT at the intersection, now heading west on Stoneface Road.
0.4	0.4	T-intersection from the left (Shawnee Road/1400E and Stoneface Road/450N). CONTINUE AHEAD.
0.5	0.9	T-intersection from the left (Stoneface Road/450N and De Neal Road/1350E). TURN LEFT onto De Neal Road. Big Saline United Baptist Church, organized in 1854, is located on the southeast corner of the T-intersection.
0.1	1.0	Coffee Cemetery on the left.
0.3	1.3	Note the view of the large sandstone bluffs to your left with an apparent dip to the south.
0.1	1.4	T-intersection from the left (Agin Grove Lane and De Neal Road/1350E). CONTINUE AHEAD.
0.2	1.6	Angled intersection from the left (De Neal Road/1350E and Somerset Road/375N). CONTINUE AHEAD. Road curves to the right just past the intersection.

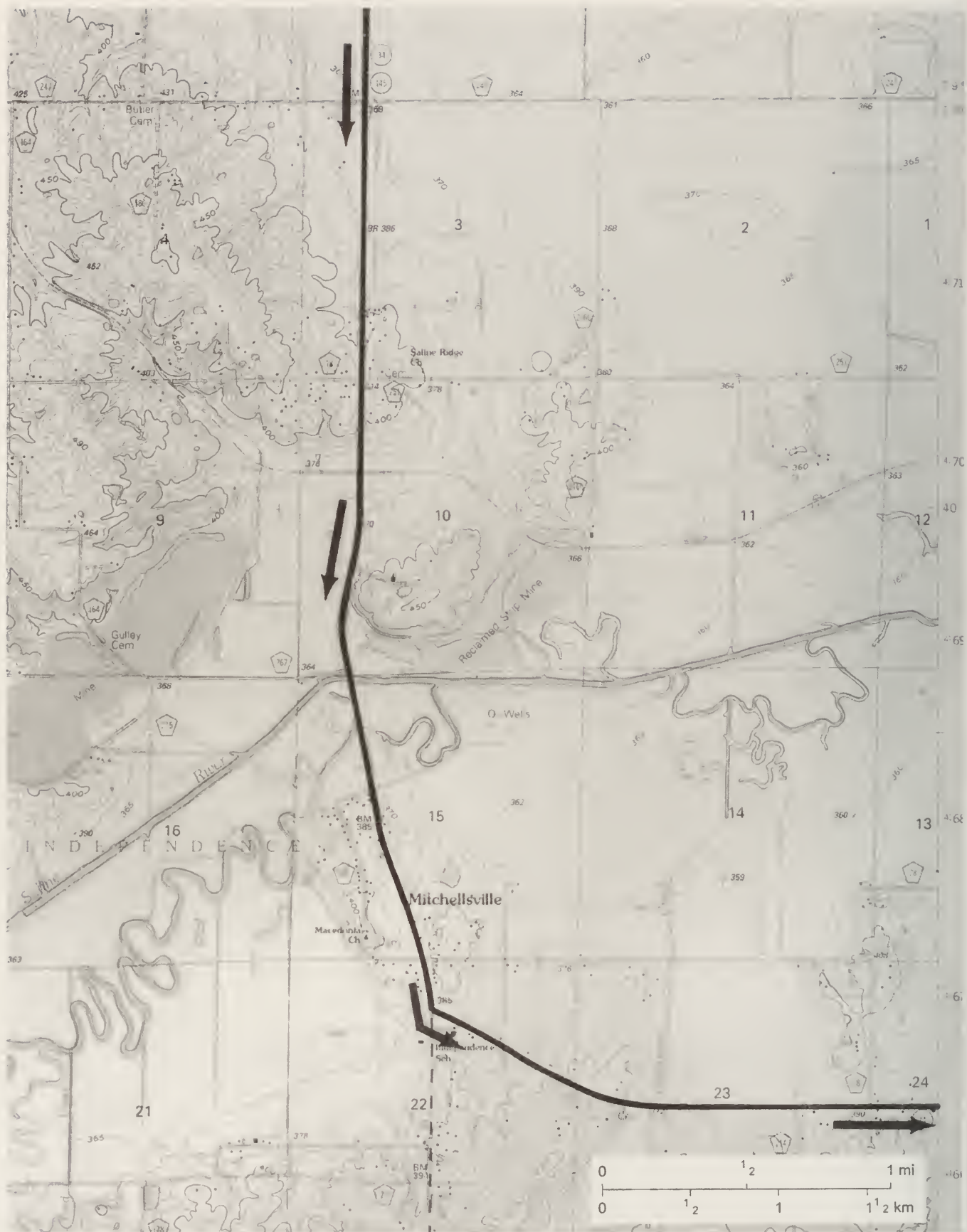
The following is from a historical sign at this intersection:

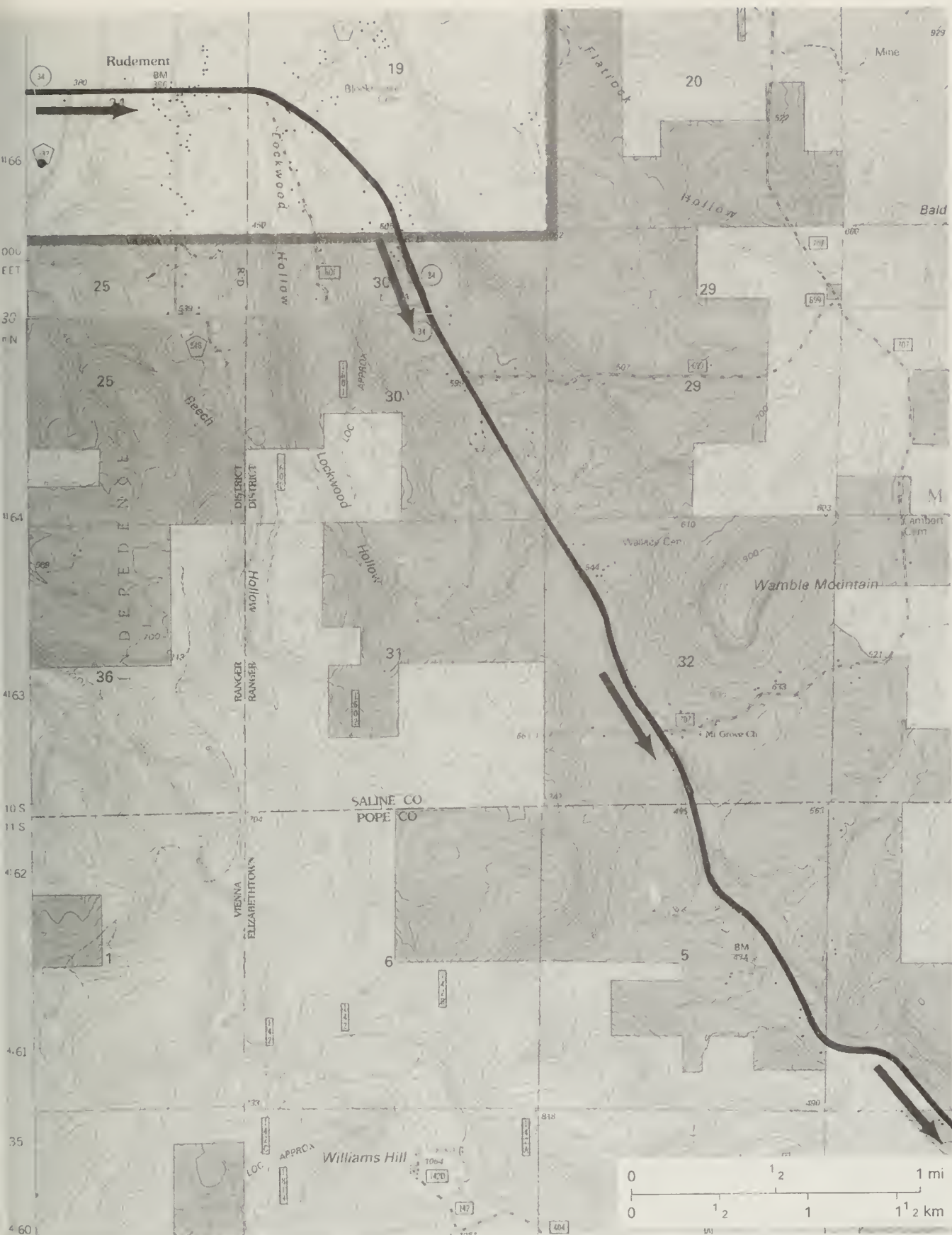
Somerset was probably the first community established in Saline County. Settlers first appeared here about 1814 though the post office was not established until 1852. A stock powered grist mill operated by the Aydelott family during this era was located about a quarter mile to the northeast. The only silver mine ever in the county was located about half a mile to the east and operated prior to 1870.

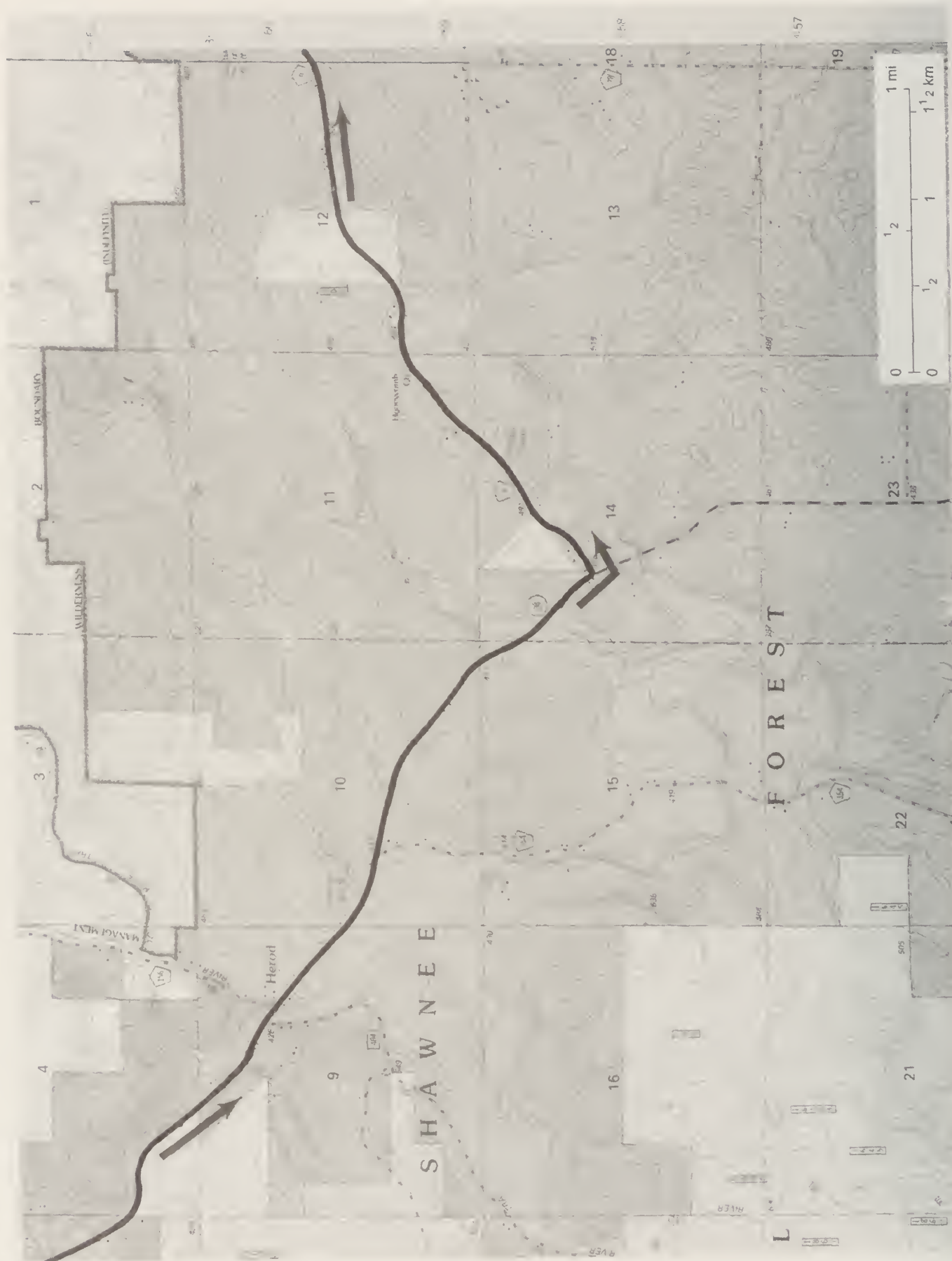
0.3	1.9	Road curves 90° to the left.
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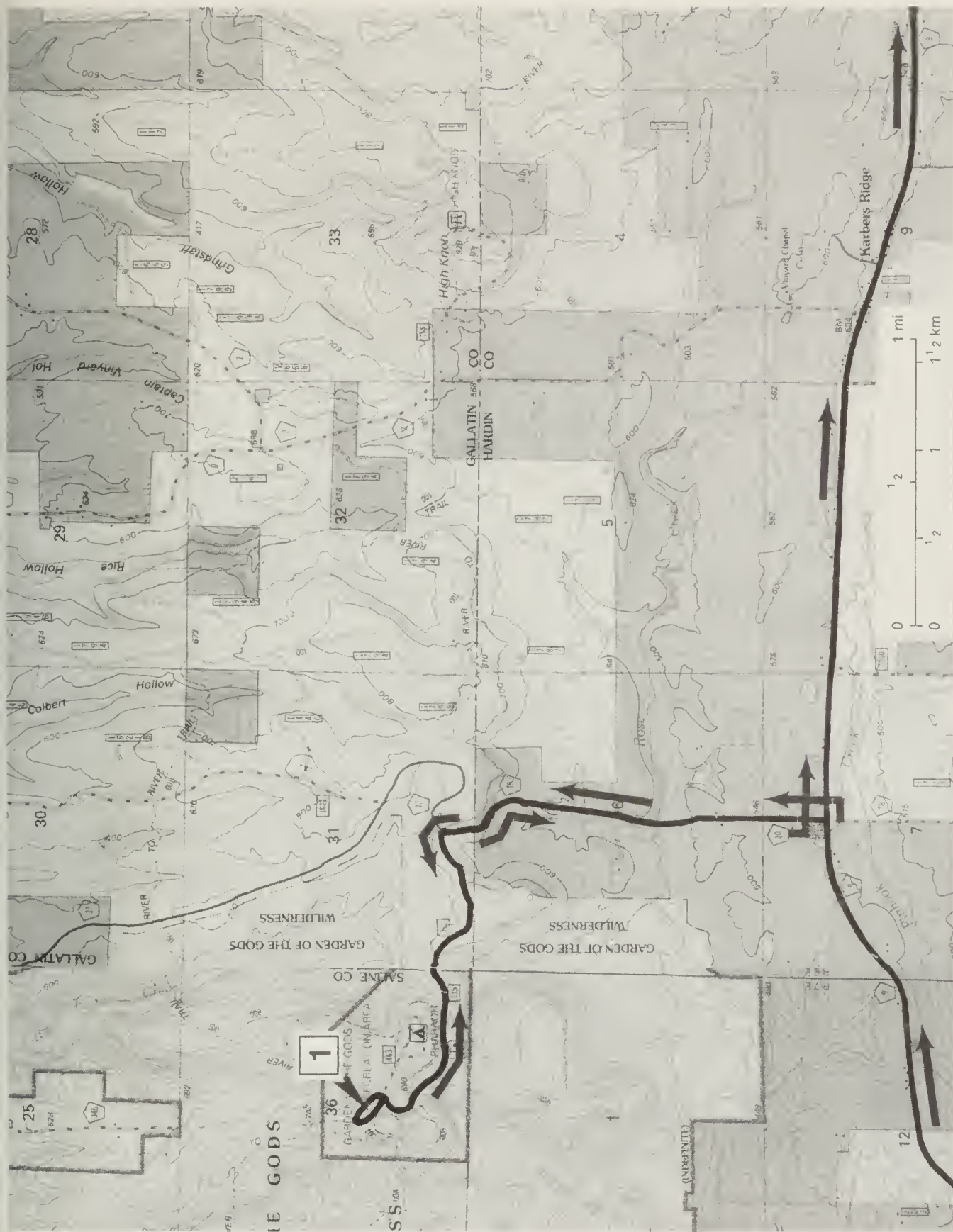
- | | | |
|-----|-----|---|
| 0.1 | 2.0 | Road curves 90° to the right. |
| 0.2 | 2.2 | Cross unnamed creek. |
| 0.6 | 2.8 | Crossroad intersection (one-way stop) from the right (De Neal Road/350N and Stoneface Road/1250E). TURN LEFT. |
| 0.7 | 3.5 | Road curves 90° to the right. |
| 0.2 | 3.7 | Cross De Neal Branch, CAUTION: narrow bridge. |
| 0.5 | 4.2 | STOP: T-intersection (Illinois Route 34/250 N and De Neal Road/1210E). TURN RIGHT onto Illinois Route 34 to return to Harrisburg, This will take you to the intersection of Illinois Routes 34 and 145. |

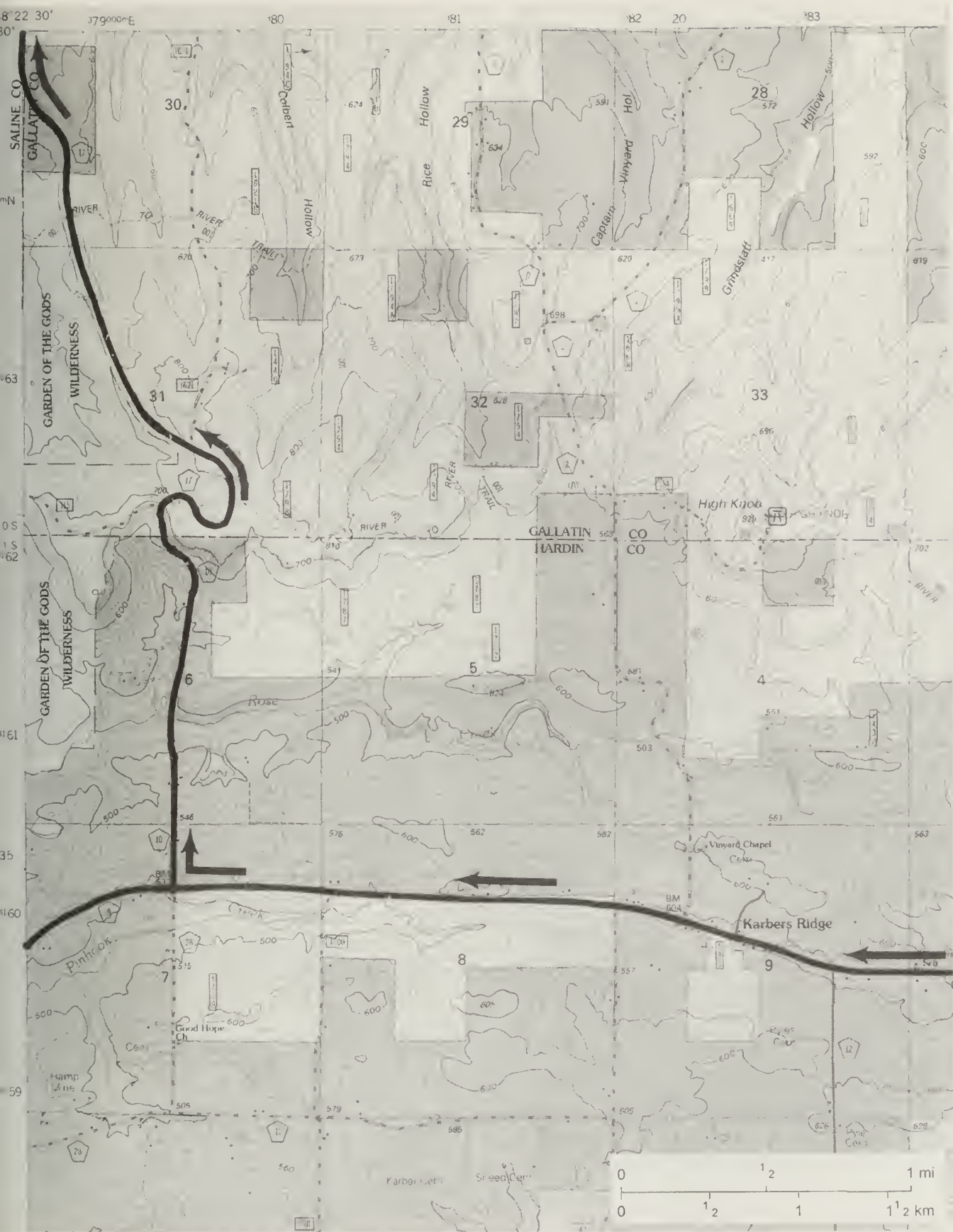




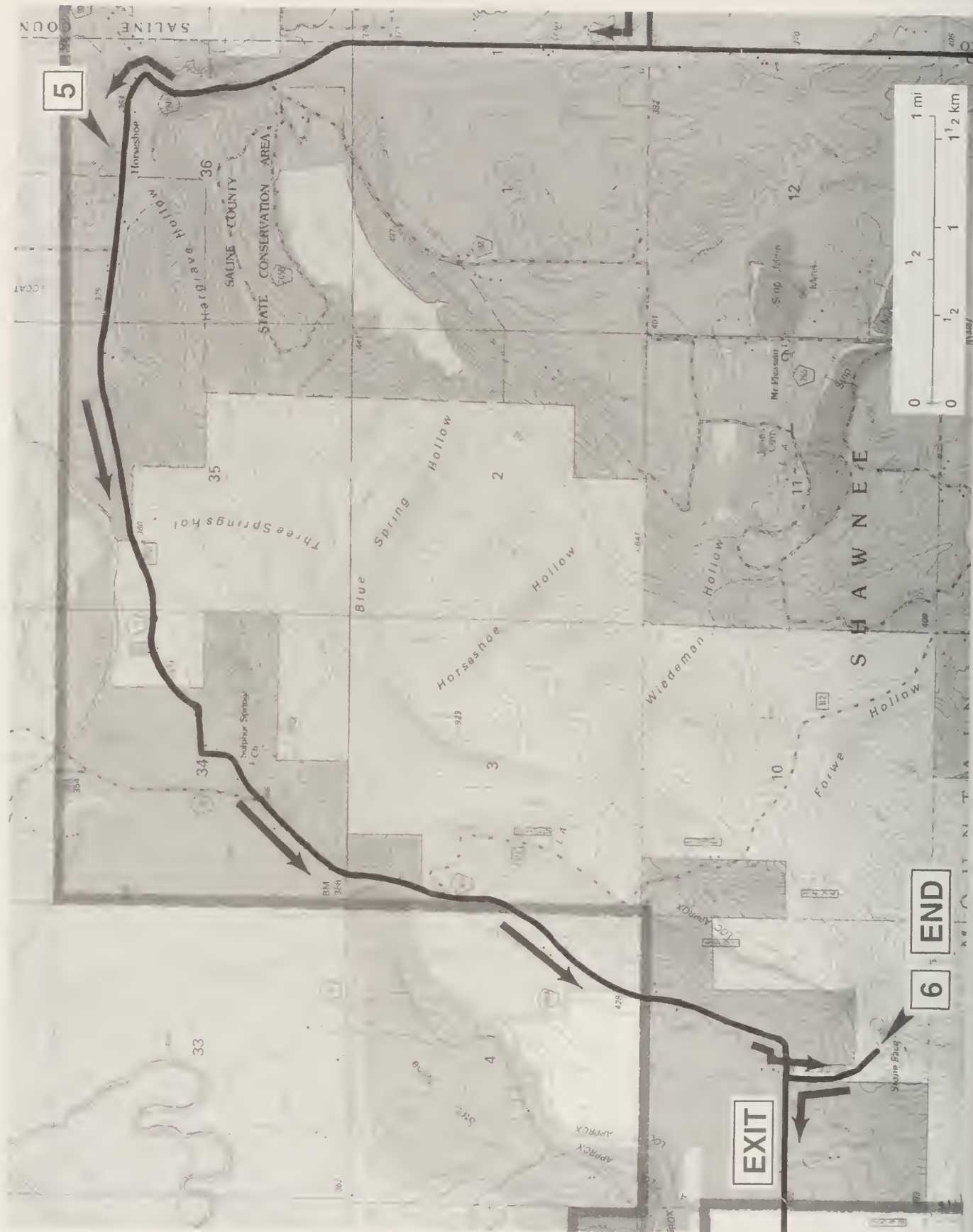


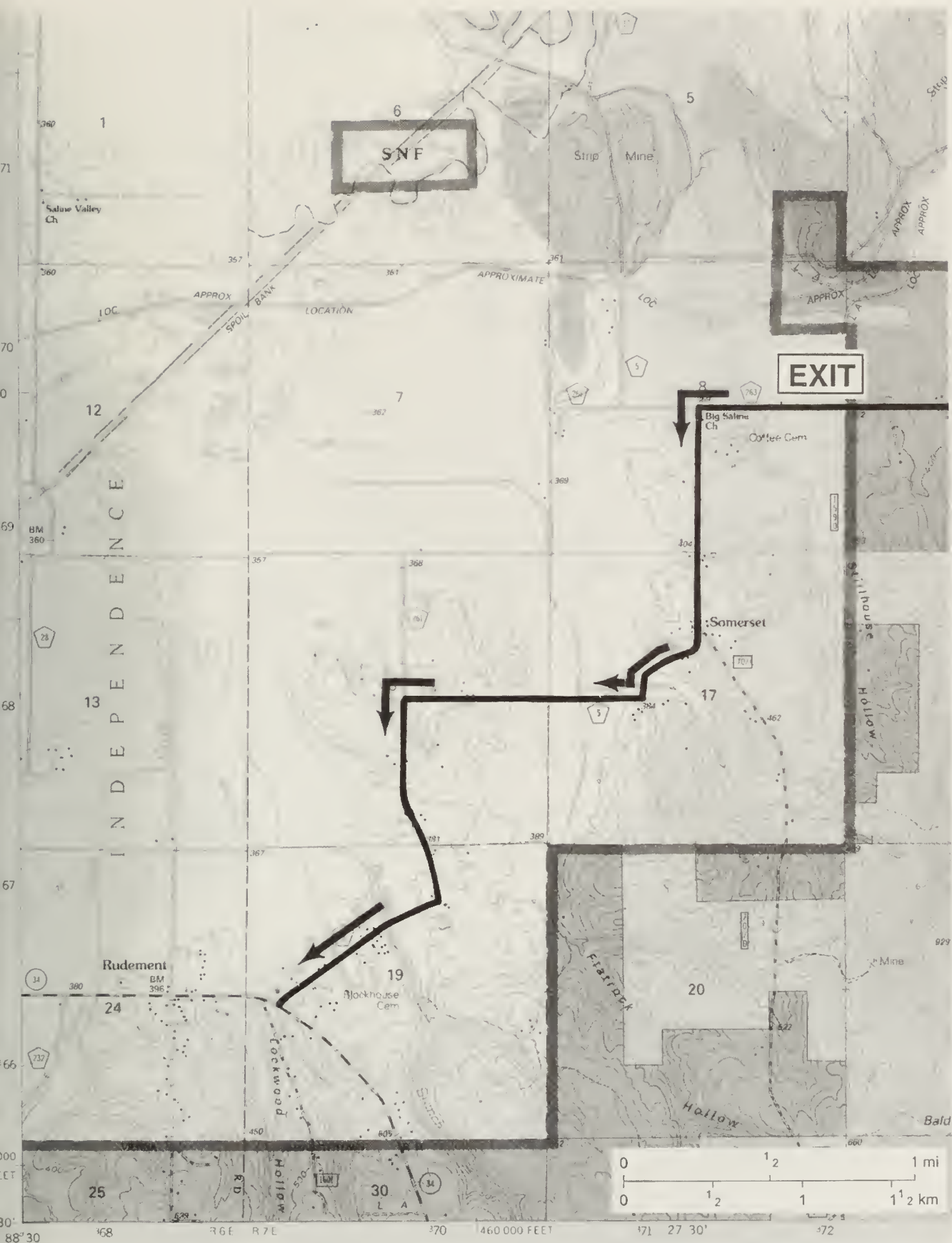












STOP DESCRIPTIONS

STOP 1: Garden of the Gods Recreation Area, Shawnee National Forest (SW, NW, SE, Sec. 36, T10S, R7E, 3rd P.M., Herod 7.5-minute Quadrangle, Saline County). (See cover photo.)

On the day of the field trip, assemble near south (left) entrance to the Observation Trail located near the middle of the upper parking lot.

We will examine the Pennsylvanian age Pounds Sandstone Member of the Caseyville Formation and discuss the structural history of the region and development of the Eagle Valley Syncline.

The Garden of the Gods Recreation Area is located in the Shawnee National Forest in southern Illinois. This area is bounded on three sides by the Garden of the Gods Wilderness Area, which was established by an act of Congress in 1990. No motorized vehicles or mechanized equipment is permitted in the 3,300-acre Garden of the Gods Wilderness Area, a relatively undisturbed wilderness area. Visitors are encouraged to “leave no trace” of their visit.

The Garden of the Gods Observation Trail is a one-fourth mile long interpretive trail. It is made of natural flagstone and leads to areas near the bluffs where there are outstanding views of the Shawnee Hills and the Garden of the Gods Wilderness Area. Starting at the south (left) entrance to the Observation Trail you will pass by many interesting rock formations, given names such as Table Rock, Camel Rock, Devil’s Smokestack, and Honeycomb Rock. The Observation Trail has some short, steep grades and a few steps, but as a whole, is not tiring. Caution should be used because there are high cliffs in the area.

GEOLOGY TIP: Glaciation stopped about 15 miles north of the Shawnee Hills. As a result, you can notice a distinct change in topography between the area near Harrisburg to the north and this area. The landscapes in the southern tip of the state are very hilly; hence, their name.

From the Garden of the Gods Recreation Area you can access the River to River and the Garden of the Gods Wilderness trail systems. Users are encouraged to obtain more detailed maps before entering the back country. Overnight parking is available at the backpackers’ parking lot.

Geological History

The Shawnee Hills took millions of years to form. The rock formations and cliffs at Garden of the Gods are made of Pennsylvanian age Pounds Sandstone and are about 320 million years old. Long ago, most of Illinois, western Indiana, and western Kentucky were covered by a giant inland sea. For millions of years, great rivers carried sand and mud to the sea where it settled along the shoreline. Over time, the weight of the accumulating sediments, and chemical reactions between the sediments and fluids in them, turned them into layers of rock, thousands of feet thick

At Garden of the Gods, the sediment layers now exposed were originally buried about one mile deep (fig. 15). Beneath the Garden of the Gods there is still some 20,000 feet of sediments piled on top of the crystalline basement. Eventually an uplift occurred, raising the land well above sea level. The uplift also fractured the bedrock, exposing it to nature’s erosive forces. Since that time, windblown sand, rain, and freezing and thawing actions have worn down the layers of sediment, creating the beautiful rock formations at Garden of the Gods. To find out more, read the signs along the observation trail.

Garden of the Gods, located on the south limb of the Eagle Valley Syncline, is one of the most scenic areas of Illinois. The rock layers exposed at the Garden of the Gods are part of the Pounds Sandstone Member of the Caseyville Formation. Long-continued erosion of the uplifted southern limb of the syncline has resulted in deeply dissected northward facing dip slopes (dip is about 10° to the north) and high knobs and ridges that consist of strongly weather-resistant sandstone.

The Pounds Sandstone is a fairly pure, slightly micaceous, quartz sandstone with numerous white rounded quartz pebbles. About 100 feet of sandstone is present in this member throughout much of the area. The sandstones of the Caseyville are very resistant to erosion, and where exposed, they are cliff-formers. The sandstones are river channel sands laid down by an ancient Pennsylvanian river system that crossed this part of Illinois from northeast to southwest. A number of sedimentary structures, typically formed by river currents within a delta system building out into and along a shallow continental sea, are well developed in the Pounds Sandstone. These sedimentary structures include wedge-shaped crossbedding and ripple marks. The purity and coarseness of the sandstone indicate that the currents along the shallow seashore (both river and nearshore currents) were swift and that much of the fine material and softer non-quartz materials were sorted out before deposition. Other noteworthy sedimentary features of the sandstone at this stop include graded bedding, bimodal sorting of the medium to coarse-grained sandstone containing white quartz pebbles, and Liesegang banding.

The unusual concentric and parallel Liesegang banding of iron oxide-rich layers in sandstone, which is so common in outcrops of the Caseyville, is well-displayed along the observation trail (fig. 16). Geologists generally attribute this banding to the so-called "Liesegang Phenomenon." For this phenomenon to occur, a fluid containing a salt must be introduced into a colloidal suspension within a porous medium (such as this coarse sandstone). During mixing of the fluid and the colloid, when the dissolved salt reaches a supersaturated level, precipitation occurs at regular intervals, resulting in the banding just described.

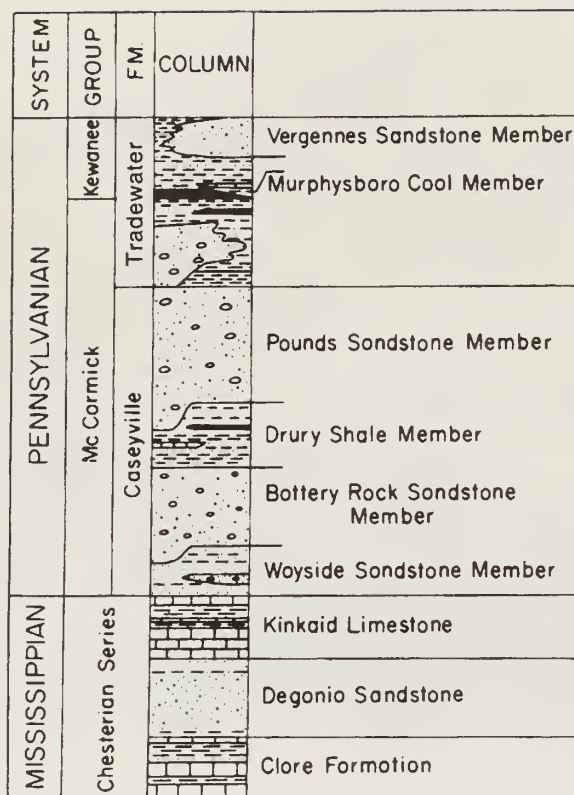


Figure 15 Generalized stratigraphic section of Mississippian and Pennsylvanian stratigraphy in the field trip area.



Figure 16 Stop 1: Liesegang banding in Pounds Sandstone, Garden of the Gods Recreation Area (photo by W.T. Frankie).

Liesegang Banding in Sandstones

The highly convoluted, dark-colored bands that stick out of the surface of some outcrops of sandstone in the Caseyville and Tradewater Formations are apparently a near-surface weathering phenomenon. The rings and banding are not observed in fresh samples of these rocks brought up in drill cores.

When these sandstones are exposed on the face of a cliff, groundwater can seep through the rock to the outer surface, carrying dissolved minerals in it. At the surface, as the water evaporates, the concentration of the minerals in the water increases, ultimately causing the minerals to precipitate out of the solution, like salt from seawater. The convoluted banding that we observe results from the interaction of this groundwater with a colloidal suspension that is already present in the pores of the rock. The bands are zones where the grains in the rock are more strongly cemented together, and weathering removes the more weakly cemented parts of the rock, leaving the strongly cemented bands standing out from the rock surface.

A colloid is a form of matter in which very fine particles are held suspended in a liquid. (Ordinary gelatin is probably the colloid that is most familiar to us.) Ferric iron (iron in its +2 or more reduced oxidation state) in solution readily forms a colloidal gel as iron hydroxide when the solution is subjected to the right chemical conditions. If the conditions that formed the colloid are then changed by the addition of a new chemical to the solution that surrounds the colloid, the tiny particles suspended in the colloid will start to clump together and form a solid. For reasons that chemists do not yet fully understand, the clumping together of the colloidal particles (called "flocculation") occurs in bands or rings in the gel, rather than uniformly. The banding apparently forms because slow and non-uniform diffusion of the added chemical into the gelatinous colloidal suspension causes a series of gradients to develop in the concentrations of the flocculating particles. The bands of color commonly observed in agate probably result from similar interactions between colloidal silica and ions dissolved in solutions that interact with the colloid. These phenomena in colloids were first studied and described by a German chemist named Liesegang.

—Jonathan H. Goodwin
Senior Geologist

Based on Krauskopf, Konrad B., 1967, *Introduction to Geochemistry*, McGraw-Hill, Inc., New York, p. 151–166.

From the high sandstone pinnacles here at Garden of the Gods, the western part of the Eagle Valley Syncline can be seen. Toward the northwest, areas of disturbed land can be seen where the Springfield, Herrin, Davis, and Dekoven Coals (Carbondale Formation, Pennsylvanian) were surface-mined (fig. 17). The distinct high ridge that is visible to the north and northwest is the northern limb of the Eagle Valley Syncline.

A syncline is a fold in which the bedrock layers have been bent downward by compressive forces acting within the earth's crust. The strata on both sides or limbs of a syncline dip (tilt) inward toward the axis or lowest part of the fold. Along the axis or central part of an eroded syncline, the youngest folded rocks are exposed. The opposite of a syncline is an anticline, in which the strata are bent upward into an arch.

The Eagle Valley Syncline (fig. 11) is an asymmetrical fold, so called because the strata in the north limb dip more steeply (10° to 25°) than the strata on the south limb (from less than 5° to 10°). The ridges that outline the syncline are formed by the eroded, upturned edges of resistant lower Pennsylvanian sandstones. These consist principally of massive sandstones of the Caseyville and Lower Tradewater Formations, which form steep, outward-facing cliffs along their outcrop belt. The top of this erosional escarpment is capped by the Grindstaff Sandstone of the Tradewater Formation. Eagle Valley itself is eroded in the softer shales and shaley sandstones of the upper Tradewater to Carbondale Formations, which overlie the more resistant sandstones. The still younger Anvil Rock Sandstone Member of the Carbondale Formation (which occurs above the Herrin Coal) is also resistant to erosion and forms the low hills in the central part of the valley along the axis of the syncline.

The axis of the syncline plunges (tilts downward) to the east, and thus the syncline is deepest and widest near the Ohio River. The syncline gradually dies out eastward into Kentucky. Near the western end of Eagle Valley, the axis bends sharply to the southwest, and the fold dies out in the vicinity of Herod. As the syncline becomes shallower and narrower westward, the sandstone ridges along its north and south limbs converge toward the axis at the nose of the syncline.

The Shawneetown Fault, a major fracture in the crust, bounds the syncline on the north and west, and faults also border the syncline to the east in Kentucky (figs. 5 and 9). These faults have large vertical displacements ranging from 500 to more than 3,500 feet. The Eagle Valley Syncline and the faults in the field trip area are part of a region of intensely disturbed Paleozoic strata that cross southern Illinois and western Kentucky (fig. 5). This region includes the Illinois fluorspar district, cut by many high-angle faults, such as the one we will observe at the abandoned Lee Mine at Stop 2.

These features were formed during a major episode of folding and faulting that began at the end of the Pennsylvanian Period about 270 million years ago. This was the time when the Appalachian Mountains were forming along the eastern margin of North America. Another episode of faulting occurred later, during the Cretaceous Period, about 100 million years ago. Recurrent movements along faults in this region have occurred since then, and earthquakes within historic time indicate that movements are still taking place.








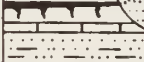












SYSTEM	SERIES	FORMATION AND MEMBER	LITHOLOGY	THICKNESS OF COAL SEAM IN INCHES	THICKNESS IN FEET
QUATERNARY	Pleistocene	Cahokia Alluvium and Equality Formation			0-150
		Loess			0-20
		Patoka Fm. West Franklin Ls. Mbr.			0-10
PENNSYLVANIAN	Shelburn Fm.	Gimlet Ss. Mbr.		0-8	0-150
		Danville (No.7) Coal Mbr.		0-36	
		Allenby Coal Mbr.		0-30	
		Anvil Rock Ss. Mbr.			
		Brereton Ls. Mbr.			
		Herrin (No. 6) Coal Mbr.		28-76	
	Carbondale Fm.	Briar Hill (No. 5A) Coal Mbr.		18-36	400-490
		St. David Ls. Mbr.			
		Turner Mine Sh. Mbr.			
		Springfield (No.5) Coal Mbr.		52-66	
		Houchin Creek (No.4) Coal Mbr.		12-18	
		Survant Coal Mbr.		6-30	
		Colchester (No.2) Coal Mbr.		0-18	
		Palzo Ss. Mbr.			
	Tradewater Fm.	Dekoven Coal Mbr.		30-42	
		Davis Coal Mbr.		36-52	
		Stonefort Ls. Mbr.		6-12	

Figure 17 Generalized stratigraphic section of Pennsylvanian stratigraphy in Eagle Valley Syncline (modified from Nelson and Lummi 1986).

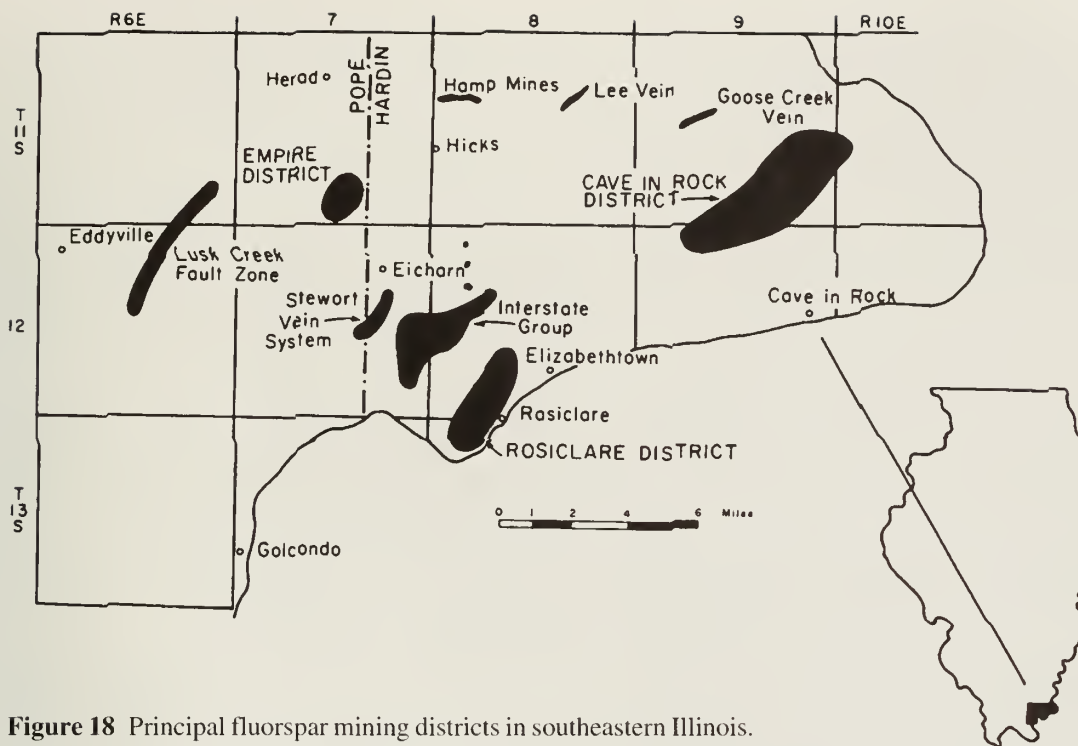


Figure 18 Principal fluorspar mining districts in southeastern Illinois.

STOP 2: Lee Mine, an abandoned fluorspar mine, Shawnee National Forest (NW, NW, NW, Sec. 14, T11S, R8E, 3rd P.M., Karbers Ridge 7.5-minute Quadrangle, Hardin County).

On the day of the field trip we will hike along the forest road, approximately 3,000 feet, to Lee Mine.

We will visit the abandoned Lee Mine located along the northern edge of the Illinois fluorspar district (fig. 18). Small samples of fluorite can be found in the old mine refuse piles.

Lee Mine was operated by Hillside Fluor Spar Mines. The company extracted ore from a vein along the Lee Fault. A generalized diagram of a fluorspar vein along a fault is shown in Figure 19. Geological mapping in this area has traced the fault 3 miles to the southwest and 5 miles to the northeast of the mine. The fault can be traced on the surface for about 1,000 feet at the mine. Although mapped as a simple fault, Lee Fault consists of several more or less parallel, closely spaced faults. At the mine this fault has a displacement of 450 feet, downthrown on the southeast side. The Cypress Sandstone forms the northwest wall, and the Menard Limestone forms the southeast wall (fig. 2). Fluorspar mineralization occurred for more than 1.5 miles along the course of the fault or fault zone.

The mine was closed in 1938 and has not been worked since then. The U.S. Bureau of Mines did exploratory drilling in the mid-1940s, but that was the extent of activities until the early 1990s when the Illinois Department of Mines and Minerals sealed the three shafts for this mine. The depths of the three shafts, depending upon their distance from the fault, ranged from 35 to 150 feet.

The ore along the fault zone occurred generally at depths of around 100 feet in the Menard Limestone, which apparently is much higher stratigraphically than is common in the fluorspar district.

Most of the fluorspar ore zones in the district are associated with the thick limestones of the St. Louis and Ste. Genevieve Formations (fig. 2). According to mine notes at the ISGS, the Lee vein was up to 6 feet wide but averaged under 4 feet, with about one-third of the vein made up of fluorite. The fault along the vein/ore body had a strike of $N47^{\circ}$ to 58° E and a dip of about 75° to 85° to the southeast. The fluorite was of high quality, and no other minerals were present in abundance, except perhaps *calcite*, and only minor amounts of galena and sphalerite.

Lee Mine is located in the northern edge of the Illinois-Kentucky fluorspar district. This region is a complexly faulted area lying between the Illinois Basin on the north and the Mississippi Embayment to the south. The Illinois portion of the district, with a history of fluorspar mining that dates from 1842, still has important deposits of minable fluorspar and related minerals.

Fluorspar from Illinois was in demand because of its high purity and the absence of the toxic trace elements often found in imported ore. Fluorite (calcium fluoride, or CaF_2), was designated as the Illinois state mineral by the 74th General Assembly in July 1965 (see Geobit 4, *Fluorite—Illinois' State Mineral*, in the back of the guidebook).

Illinois fluorspar occurs almost exclusively in Pope and Hardin Counties (fig. 18). The main production has come from the Rosiclare vein system in the Rosiclare District and from bedded replacement deposits north of the Cave-in-Rock area. Less significant amounts of fluorspar have been mined from several areas outside these main areas.

Ore Deposits

Ore bodies in the Illinois-Kentucky fluorspar mining district are of three general types: (1) bedded deposits formed by selective replacement of limestone strata, (2) fissure-filling or vein deposits along faults and fractures, and (3) residual deposits derived from one of the other types.

Vein Deposits

The mineralization at the Lee Mine is a vein-type deposit. The primary controlling factor determining the location and extent of mineralization of vein deposits is faulting. Vein deposits occur in steeply inclined, sheet-like deposits as fissure fillings along faults (fig. 19). The width and continuity of the vein deposits depend on the size of openings between the fault surfaces in which they were formed. Fault planes (surfaces) are rarely perfectly parallel. The rock surfaces on either side of a fault are generally wavy and irregular, preventing a good fit where one side of the fault

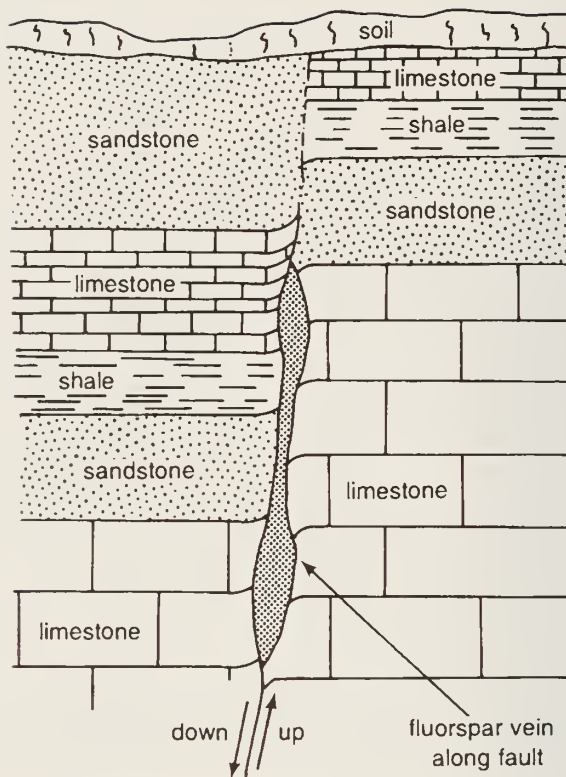


Figure 19 Diagrammatic cross section of fluorspar vein along a fault. The strata on the left side of the fault have moved downward with reference to those on the right.

plane rests against the other. These irregularities caused the opposite walls of the fault planes to be pushed apart, producing the openings in which the fluorspar veins were deposited by mineralizing solutions. As a result, the veins pinch and swell both vertically and laterally. The veins range in width from a feather edge to as much as 30 feet. Major deposits have been found in northeast-trending faults of moderate displacement (25 to 500 feet). These faults evidently provided avenues for the movement of mineralizing solutions and open fissures for mineral deposition. Faults of lesser displacement apparently failed to develop sufficient open space along fault planes, and those of greater displacement had excessive development of gouge and other heavily fractured rock that decreased the amount of available open space. Vein deposits in the Rosiclare area have been mined at depths greater than 800 feet.

Vein deposits are best developed in the stronger, more competent limestones and well-cemented sandstones in which adequate open spaces could be maintained along the faults. Weaker rocks, such as shales, sandstones, or shaley limestones, became crushed during faulting and generally filled rather than created openings. The best vein deposits are found in the relatively pure, competent Ste. Genevieve and St. Louis Limestones. Mineable vein deposits also occur in competent younger rocks of the overlying Chesterian Series, but these ore bodies are limited in size and occurrence because shale beds associated with these strata generally plugged the faults.

Mineralogy

Fluorspar (CaF_2) and calcite (CaCO_3) are the two chief minerals present in the vein deposits. Minor amounts of galena (PbS), sphalerite (ZnS), and barite (BaSO_4) also occur in some vein deposits. In the bedded deposits, fluorite is the principal ore mineral, but galena and sphalerite occur locally. Bedded ores commonly consist of alternating bands of coarse- and fine-grained fluorspar. Some banded ores also consist of alternating dark, fine-grained layers of fluorite and whole layers of calcite, forming the “coontail spar.” Rare or small amounts of strontianite, witherite, *dolomite*, pyrite, ankerite, chalcopyrite, malachite, marcasite, smithsonite, limonite, *gypsum*, aragonite, melanterite, stibnite, and sulfur have also been identified in the fluorspar deposits.

Origin of the Faults

The exact cause of the complex faulting is not known. At the end of Pennsylvanian time or during early Permian time (about 260 million years ago), the Paleozoic strata of the present Illinois-Kentucky fluorspar district may have been arched into a northwest-trending, elongate dome by an enormous rising body of *magma* (molten rock) generated at great depth. Tensional fractures were formed parallel to the long axis of the dome because of the stretching of the sedimentary strata. Some magma was squeezed into these fractures to form the dikes of dark igneous rock now exposed at the surface and in some coal mines in southeastern Illinois and western Kentucky.

After the magma had begun to cool (“crystallize”) and ceased to push upward, the area was broken by a second set of fractures oriented northeast-southwest, probably by forces related to those that were forming the Appalachian Mountains along the eastern margin of the continent. Relaxation of these forces, plus shrinkage of the body of magma as it continued to cool, caused the domed area to collapse into a series of blocks bounded by the northeast-trending fractures. The resulting *normal faults* trended northeast-southwest and became the channelways for the fluorine-bearing solutions that were probably derived from the underlying magma body. These same faults also served as deposition sites for the fluorite vein deposits. Most of the faults are normal, with fault planes inclined at high angles (70° to 80°), but some are reverse faults (fig. 3). Movement along the faults was largely vertical, but, in some places, there was also horizontal (side-ways) movement. The Shawneetown Fault Zone, a large faulted structure in Gallatin and Saline

Counties just north of the fluorspar district, shows evidence of reverse movement of as much as 3,500 feet. The compressive forces that caused this thrusting were probably also responsible for the northeast-southwest–trending fractures along which the block faulting took place.

Faulting has occurred repeatedly throughout the region since Permian time, although these later movements may be unrelated to the earlier period of faulting. Cretaceous and Tertiary strata in extreme southern Illinois and in Kentucky are also cut by faults, and *earthquakes* within recorded history suggest that movements are still taking place. The most recent major earthquakes occurred in southeastern Missouri along the New Madrid Fault in the winter of 1811–1812. Smaller earthquakes have occurred up to the present in several places.

STOP 3: LUNCH, Rim Rock Recreation Area and the Pounds Escarpment, Shawnee National Forest (NW, SW, Sec. 36, T10S, R8E, 3rd P.M., Karbers Ridge 7.5-minute Quadrangle, Gallatin County).

Following lunch, we will hike a portion of the trail to examine the flora and geology and to discuss their unique interconnection at the Pounds Escarpment.

The Rim Rock Recreation Area and the Pounds Hollow Recreation Area complex contains the Rim Rock National Recreation Trail and a Shawnee National Forest Ecological Area. The Rim Rock National Recreation Trail was constructed in 1962 and 1963, using funds contributed by the Illinois Federation of Women's Clubs. In the early 1980s, the Young Adult Conservation Corps crews replaced the original gravel path with a flagstone walkway. In 1980, the trail was designated as a National Recreation Trail. Rim Rock Trail is within a Shawnee National Forest Ecological Area, an ecosystem relatively unchanged by man. Evident along the trail are sandstone glades, relict plant associations, and interesting geological formations. Interpretive signs highlight the natural features. Rim Rock is the upper extension of Pounds Hollow, which includes about 230 acres of a designated natural area. This area is managed to protect and preserve archeological features and rare plant communities. **Help us protect the plant life and other fragile resources by staying on the trail.**

The 0.8-mile upper Rim Rock Trail meanders among native hardwoods and a cedar plantation, past the remains of the Old Indian Wall, and along the edge of the Rim Rock Escarpment made up of the Pounds Sandstone Member of the Caseyville Formation (fig. 15) that we also saw at Stop 1. The upper trail takes about one hour to walk and contains steps and some incline slopes. Wheelchair access to the observation deck is possible on the upper trail, with assistance, by going to the left on the upper trail. Steps and slopes of $\pm 8\%$ are encountered along the right portion of the upper trail and along the lower trail. The trail winds around the bluff top and in some places lies close to the edge. **Take extreme caution in rainy weather—the trail and deck surfaces may be slippery.**

The trail will take you across the Old Indian Wall, past a scenic view of Pounds Hollow Lake, and to an observation platform with a breathtaking view of the valley some 70 feet below. A stairway to the valley leads to the "Ox-Lot Cave," which is a large rock shelter in the bluff formed of Pounds Sandstone (fig. 20). Near this stairwell is "Fat Man's Misery," a narrow passage that goes through the massive sandstone bluffs and boulders.

Stepping Stones Through Time

To early settlers this formation was known as “the Pounds,” an old English term meaning “some sort of enclosure.” Throughout time, this natural escarpment and the lush valley below attracted human settlement. For prehistoric Indians, these rock formations provided protection from their neighbors, and the lush valley offered plentiful sources of food and water. After the removal of Native Americans in the 1830s, settlers spread into the interior wilderness. The forest provided an abundant source of wild game, nuts, and acorns for food and large trees to build log cabins and provide firewood for warmth on cold nights. By the late 1890s, the Pounds Hollow area was purchased by eastern land companies as part of a thriving logging enterprise, after which the land was sold to farmers. By the late 1920s, logging and farming had created an unproductive landscape. In 1936, the Shawnee National Forest acquired this land in an effort to restore the soil and forest. Today’s recreationists enjoy the natural beauty of the area, and scientists study its unique features.



Figure 20 Stop 3: Ox-Lot Cave at Rim Rock Recreation Area (photo by W.T. Frankie).

Trails

Beaver Trail is on the east side of the Pounds Escarpment (to the right), and Lower Pounds

Trail is on the west side of the Pounds Escarpment. The upper trail is a loop trail with a branch veering off to the left, which follows along the edge of the bluffs, and a branch that is straight ahead, which leads up through the Old Indian Wall. Crumbled blocks of sandstone are evident on either side of the path. The following is from a sign near the stone wall:

Why a defense? Look in front of you. . . . Can you find the remains of the ancient stone wall built by prehistoric Indians about 1,500 years ago? Archeologists believe the inhabitants, members of the Late Woodland culture, used these escarpments as a defense location. They built the wall to block the only accessible route to the top of the bluff. The wall extends almost 150 feet across the bluff top. The height of the wall is unknown, since through time, this wall has crumbled. However, early travelers reported that the walls were 6 feet in height. The stones were gathered from below the bluff, which required considerable effort. Will we be able to reconstruct the story behind the ancient wall? Archeological work has just begun on this significant site. The research will attempt to demonstrate why late woodland people were defending themselves.

The Geology of Pounds Hollow—From the Observation Platform

The Pounds Sandstone forms these spectacular bluffs. The younger Tradewater Formation underlies the gentler slopes above the sheer cliffs across the valley. These majestic sandstone bluffs began to form as sand and mud were deposited at the shoreline of the shallow sea that covered this area about 320 million years ago. Rivers originating from the north and northwest Appalachians carried the sediments down to the sea. The land was slowly sinking, and more sand and mud were

deposited on top. With time and continued burial, the sand became sandstone, mud became shale, and the peat in the swamps turned to coal.

About 280 million years ago, the land began to rise slowly, and the sea gradually retreated to its present location in the Gulf of Mexico. As this uplift began, geological forces fractured the rocks, creating channels for rainwater runoff. Since then, hundreds of feet of rocks have eroded away, and nature has gradually uncovered these geologic units, carved out Pounds Hollow (the valley below) and its tributary creeks, and sculpted the scenery now exposed at the observation platform.

A stairway at the observation platform leads to the valley floor and "Ox-Lot Cave," which is a large rock shelter in the Pounds Sandstone (fig. 20). Near this stairwell is "Fat Man's Misery," a narrow passageway between the massive sandstone bluffs. The observation platform is located on top of a large block of Pounds Sandstone that has moved westward toward the valley. Fat Man's Misery follows a curvilinear joint/fracture in sandstone trending N35°E.

Ox-Lot Cave provided shelter to many hunters and explorers who passed this way. It was not until loggers entered the hollow that the natural overhang received extensive use. A fence was built around the area to form a corral to keep the oxen, mules, and horses; hence, the name Ox-Lot Cave. The boxed-in spring, along with the shelter wall, provided a watering hole for the animals.

A narrow-gauge railroad was built within the hollow to haul cut timber in the area. Oxen dragged the heavy logs to the flat bed cars. The logs were moved to the Saline River and spiked together before being floated down on the Ohio River. Logging companies operating in the valley were profitable for a short period from 1902 to 1906. Soon thereafter, the railroad was removed.

Why is there a spring at the base of the Ox-Lot Cave? The Pounds Sandstone acts as an aquifer; rainwater percolates down through the sandstone and along fractures to the base of the bluffs. The Drury Shale Member underlies the Pounds Sandstone, and, when water encounters this unit, it begins to flow horizontally along the contact between the underlying shale and overlying sandstone. Joints/fractures concentrate the flow of groundwater. A joint trending S70°E is located near the spring. Can you find other joints in the bluff?

STOP 4A (Optional): Jader Coal Company Surface Mine, Davis and Dekoven Coal (W 1/2, NE, NW Sec. 14, T10S, R7E, 3rd P.M., Rudement 7.5-minute Quadrangle, Saline County) (fig. 21).

We will examine the mining operations of the Jader Coal Company and discuss the geology of the coals within the Eagle Valley Syncline.

The pit we will examine was opened by Jader Coal Company early this year. The company began its operations in an area that was surface-mined from 1959 to 1965 by J.W. Coal Company in the Davis and Dekoven Coal Members near the base of the Middle Pennsylvanian Carbondale Formation (fig. 17). These operations are recovering the same seams, which are separated by an interval of 20 to 30 feet. The Davis and Dekoven Coals lie roughly 200 feet below the Springfield Coal (fig. 17) that is also being mined at the Sugar Camp Mine by Black Beauty Coal. The Davis Coal is the thicker of the two seams, averaging 4 feet in thickness in most of the area, but locally up to 5 feet thick. The Dekoven Coal averages 3 feet in thickness across much of the area.



Figure 21 Stop 4: Surface mining pit at Jader Coal Company (photo by R.J. Jacobson). A view looking west in one of the pits of Jader Coal Company. At the base of the highwall to the right of trucks is the Dekoven Coal, which has been removed in this cut. The drill rig is making holes for placement of explosive that will loosen the exposed strata below the Dekoven so that the Davis Coal (about 20–30 feet below the Dekoven Coal) may be mined.

The Davis and Dekoven Coals, which have been surface-mined across much of southeastern Illinois, are economically the next most important coals after the thicker Springfield and Herrin Coals (fig.17). Because they are primarily high-sulfur coals, they have not enjoyed as much demand as western coals have in regional and national markets, since the coal market places a high premium on the cleaner, low-sulfur coals. Nevertheless, both Black Beauty and Jader Coal have reopened mining of these two coals since our last visit to the area in 1993, so they are able to successfully market these coals to utilities equipped with scrubbers to remove the sulfur dioxide from their stack gases.

In the upper part of the high wall, the Colchester Coal may also be seen. Although it is quite thin in this area, together with its overlying black shale, the Colchester Coal is one of the most widespread stratigraphic units in the middle Pennsylvanian of the Midwest (not just Illinois). Although economically important in northern Illinois, the Colchester is typically too thin to be mined in southern Illinois.

This stop also illustrates some of the important features of the Eagle Valley Syncline and the regional structure of rock strata that we have been observing as we traversed the area of the field trip. We are surrounded on the north, west, and south by massive sandstone ridges that outline the large bedrock trough or syncline of the Eagle Valley Syncline, which we discussed earlier.

The strata in the highwall (depending on the view available at time of trip) can be seen to dip significantly (as much as 14°) to the east-northeast toward the center of the syncline. We are on the western end (nose) of this eastward-plunging syncline. The mine pit is operating along the eastward-dipping cuesta of Carbondale Formation bedrock that contains the Dekoven and Davis Coals. This spot is especially interesting because Jader Coal Company has opened this pit at a spot where an older company (J.W. Coal Company) stopped operation because the depths of the Davis and Dekoven Coals put the company beyond limits that were economical to mine at the time. Jader Coal Company (formerly Jader Fuel) has been operating along the east-west cropline of the Davis and Dekoven Coals in Eagle Valley for a number of years. Just before this trip, it was operating a pit further to the east in Gallatin County. This current pit has been in operation only since the early part of this year and replaced the one in Gallatin County.

North and south of this pit, a number of companies (including Jader) have been mining the Davis and Dekoven over the years, and several mines have operated along the east-west crop south and east of here as well. Black Beauty Coal Company is the only other company currently mining either of these coals. Black Beauty is operating the Sugar Camp mine that is underground in both the Davis and Springfield Coals (the Dekoven is too thin to mine underground). Black Beauty acquired this mine from its previous owners (Coal Miners, Inc.) during the past year and are also operating a surface mine just north of the underground mine in the Herrin Coal. The company blends these coals at the Sugar Camp Mine preparation plant for sale to their buyers.

STOP 4B (Optional): Black Beauty Coal Company Wildcat Mine (Kedron Road/7000N between Sections 4 and 9, T10S, R8E, 3rd P.M., Equality 7.5-minute Quadrangle, Gallatin)

STOP 5: Horseshoe Upheaval (SW, NW, NE, Sec. 36, T9S, R7E, 3rd P.M., Rudement 7.5-minute Quadrangle, Saline County) (fig. 22).

On the day of the field trip we will hike along the gravel access road, approximately 500 feet, to the north side of the Horseshoe Upheaval.

Stop 5 is in the Horseshoe Geological Land and Water Reserve, a part of the Saline County State Fish and Wildlife Area. A sign at this stop provides a great introduction to this geologic exposure: "The Powerful Earth." The rocks in front of you are about 350 million years old. The tremendous forces of the earth forced this rock up from 3,500 feet below. These upturned rocks, known as the Horseshoe Upheaval, are silica-rich limestone and chert of the Fort Payne Formation (fig. 2). These rocks represent marine sediments deposited during the Mississippian period 350 million years ago. Several feet of the Upper New Albany Shale is also exposed at the northwest end of the upheaval. These rocks were brought to the surface along the Shawneetown Fault Zone, a great fracture zone that extends more than 100 miles across southern Illinois and western Kentucky (fig. 9).

Cave Hill to the south is composed of sandstone, shale, conglomerate, and coal of early and middle Pennsylvanian age, about 310 to 330 million years old. Coal-bearing middle Pennsylvanian rocks also underlie the low hills to the north. The Fort Payne rocks here are confined in a narrow wedge of older rocks, sandwiched by younger rocks (fig. 10). This is unusual—most faults simply have



Figure 22 Stop 5: Upturned rocks of the Fort Payne Formation at Horseshoe Upheaval (photo by W.T. Frankie).

older rocks on one side and younger rocks on the other. The Horseshoe Upheaval suggests that the Shawneetown Fault Zone underwent two episodes of movement in opposite directions. First, the rocks south of the fault zone were uplifted, bringing Fort Payne rocks to the surface, and then the southern block dropped back down. The wedge of Fort Payne rocks was sheared off and jammed in place within the fault zone. The tremendous forces involved are evident in the shattered and contorted rock layers before you.

The average strike of the strata is about N80°W, and dip is toward the south at about 60°. The rock strata seen here are part of the north limb of the Eagle Valley Syncline near a point where the syncline turns southwestward and terminates. This area is part of a large fault slice that is bounded on the north by a high-angle reverse fault with vertical displacement of at least 3,500 feet.

In an abandoned quarry, located on the northeast corner of the Horseshoe Upheaval, the Fort Payne was extracted for use as roadstone. The area covered by the abandoned quarry is about 250 feet wide and 850 feet long, a total area of about five acres. More than 200 feet of the Fort Payne Formation of the Valmeyeran Series (middle Mississippian) is exposed at the quarry site. The Fort Payne consists of highly shattered, partly silicious and calcareous shale and siltstones, and limestone. At depth, the Fort Payne consists of calcareous siltstone and limestone, but weathering has resulted in silicification (replacement by silica) of these rocks at the surface. The New Albany Shale, which consists of thin-bedded, black to dark gray carbonaceous shale that contains numerous partly phosphatic siltstone and claystone nodules, has also been intensely fractured and silicified. Calcite-filled fractures occur in the calcareous shale and siltstone of the Fort Payne Formation.

The Fort Payne Formation was deposited as an irregular tongue-shaped body in southern Illinois that partially filled a deep-water basin. The rocks of the Fort Payne Formation are intertongued with the rocks of the Borden Siltstone delta to the north and west. The Ullin Limestone, which overlies the Fort Payne Formation, is not exposed here. Uppermost units of the New Albany Group (Mississippian, Devonian) are exposed in the extreme north-western part of the quarry site. The New Albany Shale occurs at a depth of about 3,500 feet below the surface on the north side of the fault.

Intense fracturing is present in all units exposed at the quarry site. The most intensely deformed units are present near the eastern end of the quarry and about 100 feet south of the access road located on the north side of the upheaval. These crumpled and complexly deformed units consist of soft, somewhat brittle shale, which failed under shearing stresses. These soft shale units lie between siliceous siltstone and shale of the upper part of the Fort Payne Formation and thick units of the New Albany Group, which deformed competently.



Figure 23 Stop 6: Old Stone Face, Pounds Sandstone (photo by W.T. Frankie).

STOP 6: Old Stone Face (NW, SW, SE, Sec. 9, T10S, R7E, 3rd P.M., Rudement 7.5-Minute Quadrangle, Saline County) (fig. 23).

We will partake in the breathtaking view of the landscape to the west and northwest of the Eagle Valley Syncline from the top of Old Stone Face.

DO NOT GET TOO CLOSE TO THE CLIFF EDGE WHEN ON TOP.

Do not throw anything (especially the field trip leaders) over the edge.

Old Stone Face, one of the best known natural wonders of southern Illinois, is located on the southwestern edge of Cave Hill Ridge at an elevation of about 730 feet above sea level. The cliff affords a magnificent view to the north and west overlooking the low-lying Saline River Valley about 350 feet below.

The sheer cliff into which Old Stone Face has been carved by weathering and natural erosion consists of the massive, cross-bedded Pounds Sandstone Member of the Pennsylvanian age Caseyville Formation (fig. 17), which we first examined at Stops 1 and 3. The Pounds Sandstone

consists of fairly pure, slightly micaceous, quartz sandstone containing numerous white rounded quartz pebbles. The sandstone is about 100 feet thick in the field trip area.

The Caseyville sandstones are very resistant to erosion, and wherever they are exposed, they are cliff-formers. The sandstones are river-channel sands laid down by an ancient Pennsylvanian river system that crossed this part of Illinois from northeast to southwest. Current structures, including wedge-shaped cross-bedding and ripple marks, are well developed in the sandstones. The purity and coarseness of the sandstones indicate that the currents were swift.

Cave Hill Ridge forms an erosional fault scarp at the west end of Eagle Valley Syncline. In this locality, the stratigraphic displacement on the Shawneetown Fault is about 1,000 feet. The Pounds Sandstone lies 500 feet below the Saline River Valley west of Cave Hill and north of the Shawneetown Fault Zone.

End of field trip.

Drive carefully on your way home.



Figure 24 The Devil's Smokestack, Garden of the Gods Recreation Area, Shawnee National Forest (photo by R.J. Jacobson).

REFERENCES

- Buschbach, T.C., and D.R. Kolata, 1991, Regional setting of the Illinois Basin, *in* M.W. Leighton, D.R. Kolata, D.F. Oltz, and J.J. Eidel, eds., *Interior Cratonic Basins: American Association of Petroleum Geologists, Memoir 51*, p. 29–55.
- Clark, P.U., M.R. Greek, and M.J. Schneider, 1988, Surface morphology of the southern margin of the Laurentide Ice Sheet from Illinois to Montana (Abs.), *in* Program and Abstracts of the Tenth Biennial Meeting, American Quaternary Association: Amherst, University of Massachusetts, p. 60.
- Cote, W.E., D.L. Reinertsen, and M.M. Killey, 1969, Equality area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1969 A & F, 27 p. plus attachments.
- Damberger, H.H., 1971, Coalification pattern of the Illinois Basin: *Economic Geology*, v. 66, no. 3, p. 488–494.
- Killey, M.M., 1998, Illinois' Ice Age legacy: Illinois State Geological Survey, GeoScience Education Series 14, 66 p.
- Leighton, M.M., G.E. Ekblaw, and C.L. Horberg, 1948, Physiographic divisions of Illinois: Illinois State Geological Survey, Report of Investigations 129, 19 p.
- Leighton, M.W., D.R. Kolata, D.F. Oltz, and J.J. Eidel, eds., 1991, *Interior cratonic basins: American Association of Petroleum Geologists, Memoir 51*.
- Nelson, J.W., 1995, Structural features in Illinois: Illinois State Geological Survey, Bulletin 100, 144 p.
- Schwegman, J.E., 1973, Comprehensive plan for the Illinois Nature Preserve System, Part 2—Natural divisions of Illinois: Springfield, Illinois Nature Preserves Commission, 32 p.
- U.S. Geological Survey, 1997, Mineral Industry Surveys, Fluorspar 1996 and 1997 annual review: Washington, D.C., U.S. Department of the Interior.
- Willman, H.B., and J.C. Frye, 1970, Pleistocene stratigraphy of Illinois: Illinois State Geological Survey, Bulletin 94, 204 p.

RELATED READINGS

- Baxter, J.W., and G.A. Desborough, 1965, Areal geology of the Illinois fluorspar district, part 2—Karbers Ridge and Rosiclare Quadrangles: Illinois State Geological Survey, Circular 385, 40 p. plus plates.
- Bradbury, J.C., G.C. Finger, and R.L. Major, 1968, Fluorspar in Illinois: Illinois State Geological Survey, Circular 420, 64 p.
- Harris, S. E. Jr., C. W. Horrell, and D. Irwin, 1997, Exploring the land and rocks of southern Illinois—A geological guide: Carbondale, Southern Illinois University Press, p. 240.

- Herzog, B.L., B.J. Stiff, C.A. Chenoweth, K.L. Warner, J.B. Sieverling, and C. Avery, 1994, Buried bedrock surface of Illinois: Illinois State Geological Survey, Illinois Map 5; 1:500,000 scale; 33.25 inches × 60.75 inches.
- Horberg, C.L., 1950, Bedrock topography of Illinois: Illinois State Geological Survey, Bulletin 73, 111 p.
- Illinois Coal Mines Maps and Directories, Directory of Coal Mines in Illinois, Saline County, 1996: Illinois State Geological Survey, Open File Series XXXX. [Cant find as OFS.]
- Jacobson, R.J., 1993, Coal resources of the Dekoven and Davis Members (Carbondale Formation) in Gallatin and Saline Counties, southeastern Illinois: Illinois State Geological Survey, Circular 551, 41 p. plus plates.
- Lineback, J.A., et al., 1979, Quaternary deposits of Illinois: Illinois State Geological Survey Map; 1:500,000 scale; 40 inches × 60 inches; color.
- Nance, R.B., and C.G. Treworgy, 1981, Strippable coal resources of Illinois. Part 8: Central and southeastern counties: Illinois State Geological Survey, Circular 515, 32 p.
- Nelson, W.J., and D.K. Lumm, 1986a, Geologic map of the Rudement Quadrangle, Saline County, Illinois: Illinois State Geological Survey Map IGQ-3; 1:24,000 scale.
- Nelson, W.J., and D.K. Lumm, 1986b, Geologic map of the Equality Quadrangle, Gallatin and Saline Counties, Illinois: Illinois State Geological Survey Map IGQ-3; scale 1:24,000.
- Nelson, W.J., and D. K. Lumm, 1987, Structural geology of southeastern Illinois and vicinity: Illinois State Geological Survey, Circular 538, 70 p. plus plates.
- Palmer, J.E., and R.R. Dutcher, eds., 1979, Depositional and structural history of the Pennsylvanian System of the Illinois Basin. Part 1—Road log and descriptions of stops, Field Trip 9, Ninth International Congress of Carboniferous Stratigraphy and Geology: Illinois State Geological Survey, Guidebook 15b, 116 p.
- Piskin, K., and R.E. Bergstrom, 1975, Glacial drift in Illinois: Illinois State Geological Survey, Circular 490, 35 p.
- Reinertsen, D. L., W. T. Frankie, C. P. Weibel, and E. Livingston, 1994, Golconda Area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1994A, 52 p. plus attachments.
- Reinertsen, D. L., R.R. Jacobson, P.C. Reed, R.A. Bauer, and B.G. Huff, 1993, Harrisburg area: Illinois State Geological Survey, Geological Science Field Trip Guide Leaflet 1993A, 45 p. plus attachments.
- Weibel, C. P., and W. J. Nelson, 1993, Geologic map of the Lick Creek Quadrangle, Johnson, Union, and Williamson Counties, Illinois: Illinois State Geological Survey Map IGQ-12; 1:24,000 scale.

- Weller, J.M., R.M. Grogan, and F.E. Tippie, 1952, Geology of the fluorspar deposits of Illinois: Illinois State Geological Survey, Bulletin 76, 147 p. plus plates.
- Willman, H.B., E. Atherton, T.C. Buschbach, C. Collinson, J.C. Frye, M.E. Hopkins, J.A. Lineback, and J.A. Simon, 1975, Handbook of Illinois stratigraphy: Illinois State Geological Survey, Bulletin 95, 261 p.
- Willman, H.B., et al., 1967, Geologic map of Illinois: Illinois State Geological Survey Map; 1:500,000 scale; 40 inches x 56 inches; color.
- Willman, H.B., J.A. Simon, B.M. Lynch, and V.A. Langenheim, 1968, Bibliography and Index of Illinois geology through 1965: Illinois State Geological Survey, Bulletin 92, 373 p.

Glossary

The following definitions are adapted in total or in part from several sources. The principal source is R.L. Bates and J.A Jackson, eds., 1987, *Glossary of Geology*, 3rd ed.: Alexandria, Virginia, American Geological Institute, 788 p.

- ablation** Separation and removal of rock material and formation of deposits, especially by wind action or the washing away of loose and soluble materials.
- age** An interval of geologic time; a division of an epoch.
- aggrading stream** A stream that is actively depositing sediment in its channel or floodplain because it is being supplied with more load than it can transport.
- alluviated valley** One that has been at least partially filled with sand, silt, and mud by flowing water.
- alluvium** A general term for clay, silt, sand, gravel, or similar unconsolidated sorted or semisorted sediment deposited during comparatively recent time by a stream or other body of running water.
- anticline** A convex-upward rock fold in which strata have been bent into an arch; the strata on either side of the core of the arch are inclined in opposite directions away from the axis or crest; the core contains older rocks than does the perimeter of the structure.
- anticlinorium** A complex structure having smaller structures, such as domes, anticlines, and synclines superimposed on its broad upwarp.
- aquifer** A geologic formation that is water-bearing and that transmits water from one point to another.
- argillaceous** Said of rock or sediment that contains, or is composed of, clay-sized particles or clay minerals.
- arenite** A relatively clean quartz sandstone that is well sorted and contains less than 10% argillaceous material.
- base level** Lower limit of erosion of the land's surface by running water. Controlled locally and temporarily by the water level of stream mouths emptying into lakes, or more generally and semipermanently by the level of the ocean (mean sea level).
- basement complex** The suite of mostly crystalline igneous and/or metamorphic rocks that generally underlies the sedimentary rock sequence.
- basin** A topographic or structural low area that generally receives thicker deposits of sediments than adjacent areas; the low areas tend to sink more readily, partly because of the weight of the thicker sediments; the term also denotes an area of relatively deep water adjacent to shallow-water shelf areas.
- bed** A naturally occurring layer of earth material of relatively greater horizontal than vertical extent that is characterized by physical properties different from those of overlying and underlying materials. It also is the ground upon which any body of water rests or has rested, or the land covered by the waters of a stream, lake, or ocean; the bottom of a stream channel.
- bedrock** The solid rock (sedimentary, igneous, or metamorphic) that underlies the unconsolidated (non-indurated) surface materials (for example, soil, sand, gravel, glacial till, etc.).
- bedrock valley** A drainageway eroded into the solid bedrock beneath the surface materials. It may be completely filled with unconsolidated (non-indurated) materials and hidden from view.

- braided stream** A low-gradient, low-volume stream flowing through an intricate network of interlacing shallow channels that repeatedly merge and divide and are separated from each other by branch islands or channel bars. Such a stream may be incapable of carrying all of its load. Most streams that receive more sediment load than they can carry become braided.
- calcarenite** Describes a limestone composed of more or less worn fragments of shells or pieces of older limestone. The particles are generally sand-sized.
- calcareous** Said of a rock containing some calcium carbonate (CaCO_3), but composed mostly of something else (synonym: limey).
- calcining** The heating of calcite or limestone to its temperature of dissociation so that it loses its carbon dioxide; also applied to the heating of gypsum to drive off its water of crystallization to make plaster of Paris.
- calcite** A common rock-forming mineral consisting of CaCO_3 ; it may be white, colorless, or pale shades of gray, yellow, and blue; it has perfect rhombohedral cleavage, appears vitreous, and has a hardness of 3 on the Mohs scale; it effervesces (fizzes) readily in cold dilute hydrochloric acid. It is the principal constituent of limestone.
- chert** Silicon dioxide (SiO_2); a compact, massive rock composed of minute particles of quartz and/or chalcedony; it is similar to flint, but lighter in color.
- clastic** Said of rocks composed of particles of other rocks or minerals, including broken organic hard parts as well as rock substances of any sort, transported and deposited by wind, water, ice, or gravity.
- claypan (soil)** A heavy, dense subsurface soil layer that owes its hardness and relative imperviousness to higher clay content than that of the overlying material.
- closure** The difference in altitude between the crest of a dome or anticline and the lowest structural or elevation contour that completely surrounds it.
- columnar section** A graphic representation, in the form of one or more vertical column(s), of the vertical succession and stratigraphic relations of rock units in a region.
- conformable** Said of strata deposited one upon another without interruption in accumulation of sediment; beds parallel.
- cuesta** A ridge with a gentle slope on one side and a steep slope on the other.
- delta** A low, nearly flat, alluvial land form deposited at or near the mouth of a river where it enters a body of standing water; commonly a triangular or fan-shaped plain extending beyond the general trend of a coastline.
- detritus** Loose rock and mineral material produced by mechanical disintegration and removed from its place of origin by wind, water, gravity, or ice; also, fine particles of organic matter, such as plant debris.
- disconformity** An unconformity marked by a distinct erosion-produced irregular, uneven surface of appreciable relief between parallel strata below and above the break; sometimes represents a considerable time interval of nondeposition.
- dolomite** A mineral, calcium-magnesium carbonate ($\text{Ca,Mg}[\text{CO}_3]_2$); also the name applied to sedimentary rocks composed largely of the mineral. It is white, colorless, or tinged yellow, brown, pink, or gray; has perfect rhombohedral cleavage; appears pearly to vitreous; and effervesces feebly in cold dilute hydrochloric acid.
- drift** All rock material transported by a glacier and deposited either directly by the ice or reworked and deposited by meltwater streams and/or the wind.

- driftless area** A 10,000-square mile area in northeastern Iowa, southwestern Wisconsin, and northwestern Illinois where the absence of glacial drift suggests that the area may not have been glaciated.
- earthquake** Ground displacement associated with the sudden release of slowly accumulated stress in the lithosphere.
- end moraine** A ridge or series of ridges formed by accumulations of drift built up along the outer margin of an actively flowing glacier at any given time; a moraine that has been deposited at the lower or outer end of a glacier.
- epoch** An interval of geologic time; a division of a period (for example, Pleistocene Epoch).
- era** The unit of geologic time that is next in magnitude beneath an eon; it consists of two or more periods (for example, Paleozoic Era).
- escarpment** A long, more or less continuous cliff or steep slope facing in one general direction; it generally marks the outcrop of a resistant layer of rocks or the exposed plane of a fault that has moved recently.
- fault** A fracture surface or zone of fractures in Earth materials along which there has been vertical and/or horizontal displacement or movement of the strata on opposite sides relative to one another.
- flaggy** Said of rock that tends to split into layers of suitable thickness for use as flagstone.
- floodplain** The surface or strip of relatively smooth land adjacent to a stream channel produced by the stream's erosion and deposition actions; the area covered with water when the stream overflows its banks at times of high water; it is built of alluvium carried by the stream during floods and deposited in the sluggish water beyond the influence of the swiftest current.
- fluvial** Of or pertaining to a river or rivers.
- flux** A substance used to remove impurities from steel. Flux combines with the impurities in the steel to form a compound that has a lower melting point and density than steel. This compound tends to float to the top and can be easily poured off and separated from the molten steel.
- formation** The basic rock unit, one distinctive enough to be readily recognizable in the field and widespread and thick enough to be plotted on a map. It describes the strata, such as limestone, sandstone, shale, or combinations of these and other rock types. Formations have formal names, such as Joliet Formation or St. Louis Limestone (Formation), generally derived from the geographic localities where the unit was first recognized and described.
- fossil** Any remains or traces of a once-living plant or animal preserved in rocks (arbitrarily excludes recent remains); any evidence of ancient life. Also used to refer to any object that existed in the geologic past and for which evidence remains (for example, a fossil waterfall)
- fragipan** A dense subsurface layer of soil whose hardness and relatively slow permeability to water are chiefly due to extreme compactness rather than to high clay content (as in claypan) or cementation (as in hardpan).
- friable** Said of a rock or mineral that crumbles naturally or is easily broken, pulverized, or reduced to powder, such as a soft and poorly cemented sandstone.
- geology** The study of the planet Earth that is concerned with its origin, composition, and form, its evolution and history, and the processes that acted (and act) upon the Earth to control its historic and present forms.
- geophysics** Study of the Earth with quantitative physical methods. Application of the principles of physics to the study of the earth, especially its interior.
- glaciation** A collective term for the geologic processes of glacial activity, including erosion and deposition, and the resulting effects of such action on the Earth's surface.

- glacier** A large, slow-moving mass of ice formed on land by the compaction and recrystallization of snow.
- graben** An elongate, relatively depressed crustal unit or block that is bounded by faults on its long sides.
- gradient** A part of a surface feature of the Earth that slopes upward or downward; the angle of slope, as of a stream channel or of a land surface, generally expressed by a ratio of height versus distance, a percentage or an angular measure from the horizontal.
- gypsum** A widely distributed mineral consisting of hydrous calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). Gypsum is soft (hardness of 2 on the Mohs scale); white or colorless when pure but commonly has tints of gray, red, yellow, blue or brown. Gypsum is used as a retarder in portland cement and in making plaster of Paris.
- horst** An elongate, relatively uplifted crustal unit or block that is bounded by faults on its long sides.
- igneous** Said of a rock or mineral that solidified from molten or partly molten material (that is, from magma).
- indurated** Said of compact rock or soil hardened by the action of pressure, cementation, and, especially, heat.
- joint** A fracture or crack in rocks along which there has been no movement of the opposing sides (*see also* fault).
- karst** Collective term for the land forms and subterranean features found in areas with relatively thin soils underlain by limestone or other soluble rocks; characterized by many sinkholes separated by steep ridges or irregular hills. Tunnels and caves formed by dissolution of the bedrock by groundwater honeycomb the subsurface. Named for the region around Karst in the Dinaric Alps of Croatia where such features were first recognized and described.
- lacustrine** Produced by or belonging to a lake.
- Laurasia** A protocontinent of the northern hemisphere, corresponding to Gondwana in the southern hemisphere, from which the present continents of the Northern Hemisphere have been derived by separation and continental displacement. The supercontinent from which both were derived is Pangea. Laurasia included most of North America, Greenland, and most of Eurasia, excluding India. The main zone of separation was in the North Atlantic, with a branch in Hudson Bay; geologic features on opposite sides of these zones are very similar.
- lava** Molten, fluid rock that is extruded onto the surface of the Earth through a volcano or fissure. Also the solid rock formed when the lava has cooled.
- limestone** A sedimentary rock consisting primarily of calcium carbonate (the mineral, calcite). Limestone is generally formed by accumulation, mostly in place or with only short transport, of the shells of marine animals, but it may also form by direct chemical precipitation from solution in hot springs or caves and, in some instances, in the ocean.
- lithify** To change to stone, or to petrify; especially to consolidate from a loose sediment to a solid rock.
- lithology** The description of rocks on the basis of their color, structure, mineral composition, and grain size; the physical character of a rock.
- local relief** The vertical difference in elevation between the highest and lowest points of a land surface within a specified horizontal distance or in a limited area.
- loess** A homogeneous, unstratified accumulation of silt-sized material deposited by the wind.

- magma** Naturally occurring molten rock material generated within Earth and capable of intrusion into surrounding rocks or extrusion onto the Earth's surface. When extruded on the surface it is called lava. The material from which igneous rocks form through cooling, crystallization, and related processes.
- meander** One of a series of somewhat regular, sharp, sinuous curves, bends, loops, or turns produced by a stream, particularly in its lower course where it swings from side to side across its valley bottom.
- meander scars** Crescent-shaped swales and gentle ridges along a river's flood plain that mark the positions of abandoned parts of a meandering river's channel. They are generally filled in with sediments and vegetation and are most easily seen in aerial photographs.
- metamorphic rock** Any rock derived from pre-existing rocks by mineralogical, chemical, and structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment at depth in Earth's crust (examples: gneisses, schists, marbles, and quartzites)
- mineral** A naturally formed chemical element or compound having a definite chemical composition, an ordered internal arrangement of its atoms, and characteristic crystal form and physical properties.
- monolith** (a) A piece of unfractured bedrock, generally more than a few meters across. (b) A large upstanding mass of rock.
- moraine** A mound, ridge, or other distinct accumulation of glacial drift, predominantly till, deposited in a variety of topographic land forms that are independent of control by the surface on which the drift lies (*see also* end moraine).
- morphology** The scientific study of form and of the structures and development that influence form; term used in most sciences.
- natural gamma log** One of several kinds of measurements of rock characteristics taken by lowering instruments into cased or uncased, air- or water-filled boreholes. Elevated natural gamma radiation levels in a rock generally indicate the presence of clay minerals.
- nickpoint** A place with an abrupt inflection in a stream profile, generally formed by the presence of a rock layer resistant to erosion; also, a sharp angle cut by currents at base of a cliff.
- nonconformity** An unconformity resulting from deposition of sedimentary strata on massive crystalline rock.
- nonlithified** Said of unconsolidated materials.
- normal fault** A fault in which the hanging wall appears to have moved downward relative to the footwall.
- outwash** Stratified glacially derived sediment (clay, silt, sand, and gravel) deposited by meltwater streams in channels, deltas, outwash plains, glacial lakes, and on flood plains.
- outwash plain** The surface of a broad body of outwash formed in front of a glacier.
- oxbow lake** A crescent-shaped lake in an abandoned bend of a river channel. A precursor of a meander scar.
- Pangea** The supercontinent that existed from 300 to 200 million years ago. It combined most of the continental crust of the Earth, from which the present continents were derived by fragmentation and movement away from each other by means of plate tectonics. During an intermediate stage of the fragmentation, between the existence of Pangea and that of the present widely separated continents, Pangea was split into two large fragments, Laurasia on the north and Gondwana in the southern hemisphere.

- ped** Any naturally formed unit of soil structure (examples: granule, block, crumb, or aggregate).
- peneplain** A land surface of regional scope worn down by erosion to a nearly flat or broadly undulating plain.
- period** An interval of geologic time; a division of an era (examples: Cambrian, Jurassic, and Tertiary).
- physiography** The study and classification of the surface features of Earth on the basis of similarities in geologic structure and the history of geologic changes.
- physiographic province (or division)** (a) A region, all parts of which are similar in geologic structure and climate and which has consequently had a unified geologic history. (b) A region whose pattern of relief features or landforms differs significantly from that of adjacent regions.
- point bar** A low arcuate ridge of sand and gravel developed on the inside of a stream meander by accumulation of sediment as the stream channel migrates toward the outer bank.
- radioactivity logs** Any of several types of geophysical measurements taken in bore holes using either the natural radioactivity in the rocks, or the effects of radiation on the rocks to determine the lithology or other characteristics of the rocks in the walls of the borehole (examples: natural gamma radiation log; neutron density log).
- relief** (a) A term used loosely for the actual physical shape, configuration, or general unevenness of a part of Earth's surface, considered with reference to variations of height and slope or to irregularities of the land surface; the elevations or differences in elevation, considered collectively, of a land surface (frequently confused with topography). (b) The vertical difference in elevation between the hilltops or mountain summits and the lowlands or valleys of a given regional extent. Formed in places where the forces of plate tectonics are beginning to split a continent (for example, East African Rift Valley).
- rift** (a) A narrow cleft, fissure, or other opening in rock made by cracking or splitting; (b) a long, narrow continental trough that is bounded by normal faults—a graben of regional extent.
- sediment** Solid fragmental matter, either inorganic or organic, that originates from weathering of rocks and is transported and deposited by air, water, or ice or that is accumulated by other natural agents, such as chemical precipitation from solution or secretion from organisms. When deposited, sediment generally forms layers of loose, unconsolidated material (examples: sand, gravel, silt, mud, till, loess, and alluvium).
- sedimentary rock** A rock resulting from the consolidation of loose sediment that has accumulated in layers (examples: sandstone, siltstone, mudstone, and limestone).
- shoaling** Said of an ocean or lake bottom that becomes progressively shallower as a shoreline is approached. The shoaling of the ocean bottom causes waves to rise in height and break as they approach the shore.
- silt** A rock fragment or detrital particle smaller than a very fine sand grain and larger than coarse clay, having a diameter in the range of 4 to 62 microns; the upper size limit is approximately the smallest size that can be distinguished with the unaided eye.
- sinkhole** Any closed depression in the land surface formed as a result of the collapse of the underlying soil or bedrock into a cavity. Sinkholes are common in areas where bedrock is near the surface and susceptible to dissolution by infiltrating surface water. Sinkhole is synonymous with "doline," a term used extensively in Europe. The essential component of a hydrologically active sinkhole is a drain that allows any water that flows into the sinkhole to flow out the bottom into an underground conduit.
- slip-off slope** Long, low, gentle slope on the inside of a stream meander. The slope on which the sand that forms point bars is deposited.

- stage, substage** Geologic time-rock units; the strata formed during an age or subage, respectively. Generally applied to glacial episodes (for example, Woodfordian Substage of the Wisconsin Stage).
- stratigraphic unit** A stratum or body of strata recognized as a unit in the classification of the rocks of Earth's crust with respect to any specific rock character, property, or attribute or for any purpose such as description, mapping, and correlation.
- stratigraphy** The study, definition, and description of major and minor natural divisions of rocks, particularly the study of their form, arrangement, geographic distribution, chronologic succession, naming or classification, correlation, and mutual relationships of rock strata.
- stratum** A tabular or sheet-like mass, or a single, distinct layer of material of any thickness, separable from other layers above and below by a discrete change in character of the material, a sharp physical break, or both. The term is generally applied to sedimentary rocks but could be applied to any tabular body of rock (*see also* bed).
- subage** A small interval of geologic time; a division of an age.
- syncline** A convex-downward fold in which the strata have been bent to form a trough; the strata on either side of the core of the trough are inclined in opposite directions toward the axis of the fold; the core area of the fold contains the youngest rocks (*see also* anticline).
- system** A fundamental geologic time-rock unit of worldwide significance; the strata of a system are those deposited during a period of geologic time (for example, rocks formed during the Pennsylvanian Period are included in the Pennsylvanian System).
- tectonic** Pertaining to the global forces that cause folding and faulting of the Earth's crust; also used to classify or describe features or structures formed by the action of those forces.
- tectonics** The branch of geology dealing with the broad architecture of the upper (outer) part of Earth; that is, the major structural or deformational features, their origins, historical evolution, and relations to each other. It is similar to structural geology, but generally deals with larger features such as whole mountain ranges or continents.
- temperature-resistance log** A borehole log, run only in water-filled boreholes, that measures the water temperature and the quality of groundwater in the well.
- terrace** An abandoned floodplain formed when a stream flowed at a level above the level of its present channel and floodplain.
- till** Nonlithified, nonsorted, unstratified drift deposited by and underneath a glacier and consisting of a heterogeneous mixture of different sizes and kinds of rock fragments.
- till plain** The undulating surface of low relief in an area underlain by ground moraine.
- topography** The natural or physical surface features of a region, considered collectively as to form; the features revealed by the contour lines of a map.
- unconformable** Said of strata that do not succeed the underlying rocks in immediate order of age or in parallel position. A general term applied to any strata deposited directly upon older rocks after an interruption in sedimentation, with or without any deformation and/or erosion of the older rocks.
- valley trains** The accumulations of outwash deposited by rivers in their valleys downstream from a glacier.
- water table** The point in a well or opening in the Earth where groundwater begins. It generally marks the top of the zone where the pores in the surrounding rocks are fully saturated with water.
- weathering** The group of processes, both chemical and physical, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil.

THE NATURAL AND HUMAN HISTORY OF THE SHAWNEE NATIONAL FOREST

Presettlement Forests

One popular myth is that, prior to European contact, America was dominated by impenetrable, relatively uniform, ancient forests that cloaked the landscape in a static, long-term ecological balance with the environment. The reality was quite the contrary. Presettlement forests were dynamically shaped by a myriad of natural and human influences, disturbances, and catastrophic events. These events profoundly affected the age, plant species, and wildlife of the forest environment. Presettlement forests in both the East and West were a diverse mosaic of forest stands, widely varying in age, tree species, and wildlife and reflecting historical disturbances.

The area that is now the Shawnee National Forest has a rich history. Before European settlement, the Shawnee was positioned at the western edge of the great forest that blanketed eastern North America. The Shawnee was on the eastern and southern fringe of the vast American tall grass prairie that stretched for hundreds of miles beyond the Mississippi. Thus, the area was in a dynamic transition zone between forest and prairie.

Presettlement forests in Illinois included oak savannahs and grasslands and open, park-like stands of upland oak woodland carpeted with grass and wildflowers. The oak woodland itself was interspersed with prairie openings and glades.

These presettlement forests were not pristine in the sense of being uninfluenced by humans. The forests were strongly influenced by the Native Americans who lived in fixed villages within them. Domesticated crops accounted for two-thirds or more of these Native Americans' diet, which depended on maize-based agriculture. A relatively recent development in eastern North America, having come into widespread use only about 800–1,000 A.D., maize-based agriculture resulted in Native American population densities that were at least five times that of the nomadic, hunter/gatherer societies to the north and west.

In the forests of the present-day Midwest, thousands of acres were cleared for fields while thousands more were burned frequently to improve game habitat, facilitate travel, reduce insect pests, remove cover for potential enemies, enhance conditions for berries, and drive game. Agricultural areas shifted frequently: fields and villages were abandoned when their natural fertility ran out, new forests were cleared, and abandoned lands quickly reverted back to forest.

The abundant wildlife that was reported to have existed in the area also gives an indication of the frequency of disturbance! Deer, wild turkeys, and a variety of game birds abounded; all of those species are associated with forest edge habitats.

Yet, perhaps the most important influence shaping the forest landscape was wildfires. Frequent wildfires, started both naturally by lightning or set intentionally or inadvertently by Native Americans, was a dominant force in shaping the open, park-like, woodland and prairie landscapes as well as the plant and animal communities that were associated with them. Fire-created prairies extended well into Ohio. Evidence of the dominant role fire played in these forests is demonstrated by the fact that, when farms finally began to move out on to the prairies, cutting off prairie fires, millions of acres of open oak savannahs and even treeless prairies to the east of these farms became dense forests within two decades.

As we in the present day see rising concern over the need to protect some of our forests in their “natural” condition, the complex natural and presettlement human history of these forests raises equally complex technical and policy questions over whether and how to allow wildfire to assume its natural role in these areas as well as whether to seek to replicate presettlement human influences. We know that it is virtually impossible to separate natural from human influences in presettlement forests. North American forests have been both occupied and influenced by humans from the time these forests advanced north before the retreating continental glaciers 8,000 years ago.

Forests After European Settlement

There is no doubt that the era of European settlement vastly increased the impact of humans on the forests in the area that is now the Shawnee National Forest. After 1800, settlers by the thousands poured into the Ohio and Mississippi River valleys. Between 1810 and 1820, the population of Ohio doubled, that of Indiana increased six times, from less than 25,000 to almost 150,000. Hardwood forests, which at the time were thought to occupy the best farm land, were particularly sought after. The wave of settlers first sought the rich land next to rivers and major streams, but soon moved up the slopes into the hills between the river valleys. The forests fell rapidly under this onslaught.

Forests were cleared not only because they occupied productive farm land, but also because they provided fuel for domestic heating and cooking as well as providing fencing and building materials for barns, homes, outbuildings, and myriad other products needed in the development of the area. Forests also provided the fuel for steamboats and railroads that linked midwestern farms to the growing cities of the East. Until 1850, most U.S. iron was produced using wood charcoal. There were a number of iron furnaces in the area of the Shawnee.

Sawmills were introduced into the area, accompanying the rapid increase in towns and villages. The common practice, known as “high grading,” was to cut only the desired high-value species. This practice resulted in residual stands of trees that were defective, misshapen, and generally of low value. Unfortunately, this logging practice has been continued to modern times—under the guise of “selection management”—by some logging operations, which take commercially useful trees only, leaving behind inferior trees.

The Nature of Present-Day Forests of Illinois

Present-day forests in Illinois reflect their natural and human history. Stands that were logged in the late 1800s for fuel wood and other uses regenerated to a mixture of tree species that are essentially even-age. Because the slower growing, understory-tolerant species may take 40 years longer—or more—to mature than do the intolerant species, these early cuttings produced stands that were not only a mixture of species but also a mixture of sizes. Such stands are often mistaken for all-aged, even though they are even-aged.

Harvest in Illinois forest lands increased until the turn of the century, but then declined steadily because of the earlier harvesting. Commercial forest lands in Illinois have continued to undergo changes. Between 1962 and 1985, more than half of the state’s bottom land hardwood types had been eliminated, either through disease or conversion to other land uses. During this same period, due primarily to the exclusion of fire from the forest, the upland oak-hickory type decreased by 12%, and the maple-beech increased by over 1,100%. Using the 1985 forest inventory of Illinois, the forest cover types of the Shawnee can be placed into four major type groups: upland oak-hickory (69.6%), pine (18.0%), bottom land hardwoods (7.6%), and maple-beech (4.8%).

The Shawnee National Forest

In the late 1800s, there began a growing tide of land abandonment and reversion to forest, particularly of marginal farm land east of the Mississippi. Marginal agricultural land in the area of the present-day Shawnee began to be abandoned as its productivity was depleted and more productive farm lands opened up elsewhere. This process was accelerated by the Great Depression.

Under the Resettlement Act, a New Deal program, thousands of farmers on marginal farm lands in the East and South were relocated to more productive land. Between 1925 and 1945, almost 20 million acres of their abandoned farms were incorporated into the eastern national forests under the Weeks Act. Millions of additional acres became state parks and forests.

In 1939, the Shawnee National Forest was established as part of this program. Soon after acquisition, feral cattle, dogs, and goats were eliminated, and the land was rehabilitated. Rehabilitation was accelerated by CCC (Civilian Conservation Corps) crews who planted fast-growing southern pine trees on worn-out and eroding croplands and pastures.

Today, these rehabilitated lands support productive forests that provide superb habitat for rich populations of many wildlife species, some of which had not existed on these lands for a century or more. Because of its settlement history, the forests of the Shawnee are relatively young. Only 13% of the forest has stands that are over 100 years old. There are no old growth or “ancient” forests of the kind that exist on the Pacific Coast. In fact, even the presettlement forests that existed in the area of the Shawnee were open-grown, one-storied, park-like stands, interspersed with prairies. These forests were far different—both visually and ecologically—from the closed-canopied, multi-storied, old-growth forests of the coastal temperate rainforests.

Acknowledgments

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Reference Sources

Clawson, M., 1979, Forests in the long sweep of American history: *Science*, v. 204, p.1168–1174.

Cronon, W., 1985, *Changes in the land: Indians, colonists, and the ecology of New England*: New York, Hill and Wang.

Den Uyl, Daniel, 1962, The central region, *in* Barrett, John W., ed., *Regional silviculture of the United States*, New York: Ronald Press Co., 610 p.

Fedkiw, J., 1989, The evolving use and management of the nation’s forests, grasslands, croplands, and related resources: USDA-Forest Service, General Technical Report RM-175, September 1989.

Frederick, K.D., and R.A. Sedjo, eds., 1991, *America’s renewable resources: Historical trends and current challenges: Resources for the Future*, Washington, D.C.

Gibbs, C.B., 1963, Tree diameter—A poor indicator of age in West Virginia hardwoods. Research Paper NE-11: Upper Darby, Pennsylvania, U.S. Department of Agriculture, Forest Service, Northeast Experiment Station, 4 p.

- Hahn, J.T., 1987, Illinois forest statistics, 1985, Resource Bulletin NC-103: St. Paul, Minnesota, U.S. Department of Agriculture, Forest Service, North Central Experiment Station, 101 p.
- Horwitz, E.C.J., 1974, Clearcutting—A view from the top: Washington, D.C., Acropolis Books, 179 p.
- Marquis, D. A., R.L. Ernst, and S.L. Stout, 1984, Prescribing silvicultural treatments in hardwood stands of the Alleghenies, Gen. Tech. Report NE-96: Broomall, Pennsylvania, U.S. Department of Agriculture, Forest Service, Northeastern Station, 90 p.
- Marquis, D. A., and R.L. Johnson, 1989, Silviculture of eastern hardwoods, *in* The scientific basis for silvicultural and management decisions in the national forest system, Agricultural General Technical Report WO-55: Washington, D.C., U.S. Department of Agriculture, Forest Service, 180 p.
- Roach, B.A., and S.F. Gingrich, 1968, Even-aged silviculture for upland central hardwoods, Agriculture Handbook 355: Washington, D.C., U.S. Department of Agriculture, Forest Service, 39 p.
- Rolfe, G.L., chairman, 1990, A long range plan for Illinois forest resources: Urbana, Illinois, Illinois Council on Forestry Development, 56 p.
- Steen, H.K., 1976, The U.S. Forest Service—A history: Seattle, Washington, University of Washington Press.
- Trefethen, J.B., 1975, An American crusade for wildlife: New York, Winchester Press and the Boone and Crockett Club.
- U.S. Bureau of the Census. 1975. Historical statistics of the United States from colonial times to 1970, Bicentennial edition, part 1: Washington, D.C., U.S. Department of Commerce.
- Westveld, R.H., 1949, Applied silviculture in the United States: New York, John Wiley & Sons, 590 p.
- Williams, M., 1989, Americans and their forests—An historical geography: New York, Cambridge University Press.

Depositional History of the Pennsylvanian Rocks in Illinois

At the close of the Mississippian Period, about 320 million years ago, the sea withdrew from the Midwest. During this earliest Pennsylvanian time, erosion removed hundreds of feet of the pre-Pennsylvanian strata, stripping them away and cutting into older rocks. Ancient river systems scoured deep channels into the bedrock surface. Later, but also during early Pennsylvanian time, the sea level began to rise, interrupting the erosion and leading to filling of the valleys in the erosion surface with fluvial, brackish, and marine sands and muds.

During most of Pennsylvanian time, the Illinois Basin gradually subsided, leading to the accumulation and preservation of about 3,000 feet of Pennsylvanian sediments in the basin. Depositional conditions in the Illinois Basin during the Pennsylvanian were similar to those during the preceding late Mississippian. A river system flowed southwestward across a swampy lowland, carrying mud and sand from the highlands located to the northeast. This river system formed thin but widespread deltas that coalesced into a vast coastal plain or lowland that prograded (built out) into the shallow sea that covered much of present-day Illinois (see paleogeographic map, to the right). Because the lowland stood only a few feet above sea level, slight changes in relative sea level caused great shifts in the position of the shoreline.

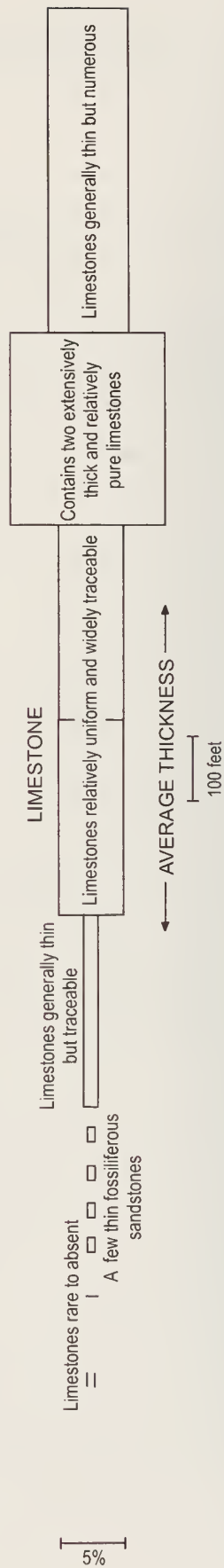
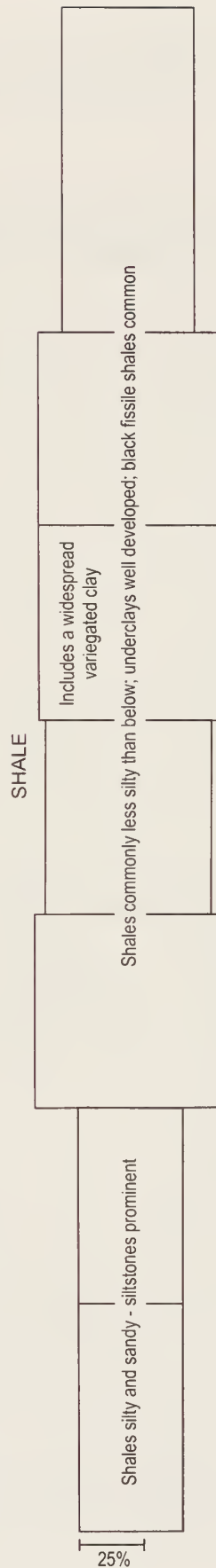
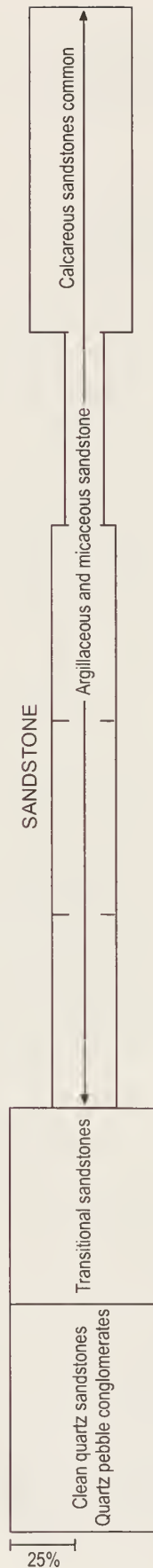
The locations of the delta systems and the shorelines of the resulting coastal plain shifted, partly because of world-wide sea level changes, but also because of variations in the amount of sediment provided by the river systems and local changes in basin subsidence rates. These frequent shifts in the coastline position caused the depositional conditions at any one locality in the basin to alternate frequently between marine and nonmarine, producing a variety of lithologies in the Pennsylvanian rocks (see lithology distribution chart, on page 2).



Paleogeography of the Illinois-Indiana region during Pennsylvanian time. The diagram shows a Pennsylvanian river delta and the position of the shoreline and the sea at an instant of time during the Pennsylvanian Period.



RACCOON CREEK GROUP		MCLEANSBORO GROUP			
Caseyville Fm.	Tradewater Fm.	Carbondale Fm.	Shelburn	Patoka	Bond Fm.
					Mattoon Fm.



General distribution of the four principal lithologies in Pennsylvanian strata of Illinois.



Conditions at various places on the shallow sea floor favored the deposition of sand, mud, or lime mud. Sand was deposited near the mouths of distributary channels, where it was reworked by waves and spread out as thin sheets near the shore. Mud was deposited in quiet-water areas—in delta bays between distributaries, in lagoons behind barrier bars, and in deeper water beyond the nearshore zone of sand deposition. Limestone was formed from the accumulation of the limy parts of animals and marine plants that were laid down in areas where only minor amounts of sand and mud were being deposited. The areas of sand, mud, and limy mud deposition continually shifted as the position of the shoreline changed and as the delta distributaries extended seaward or shifted their positions laterally along the shore.

Nonmarine sand, mud, and lime mud were deposited on the coastal plain bordering the sea. The nonmarine sand was deposited in delta distributary channels, in river channels, and on the broad floodplains of the rivers. Some sand bodies 100 or more feet thick were deposited in channels that cut through the underlying rock units by rivers. Mud was deposited mainly on floodplains. Some mud and freshwater lime mud were deposited locally in freshwater lakes and swamps.

Because of plate tectonics, Illinois was located close to the equator at this time. Beneath the quiet water, in the extensive swamps that prevailed for long intervals on the emergent coastal lowland, peat was formed, by accumulation of plant material. Lush forest vegetation covered the region; it thrived in the warm, moist Pennsylvanian-age tropical climate. The origin of the underclays beneath the coal is not precisely known, but most evidence indicates that they were deposited in the swamps as slackwater mud before the accumulation of significant plant debris. The underclays represent the soils upon which the lush vegetation grew in the swamps. Underclay commonly contains plant roots and rootlets that appear to be in their original growth position. The vast swamps were the culmination of nonmarine deposition. Resubmergence of the borderlands by the sea commonly interrupted nonmarine deposition, and, when this happened, marine sediments were laid down over the past.

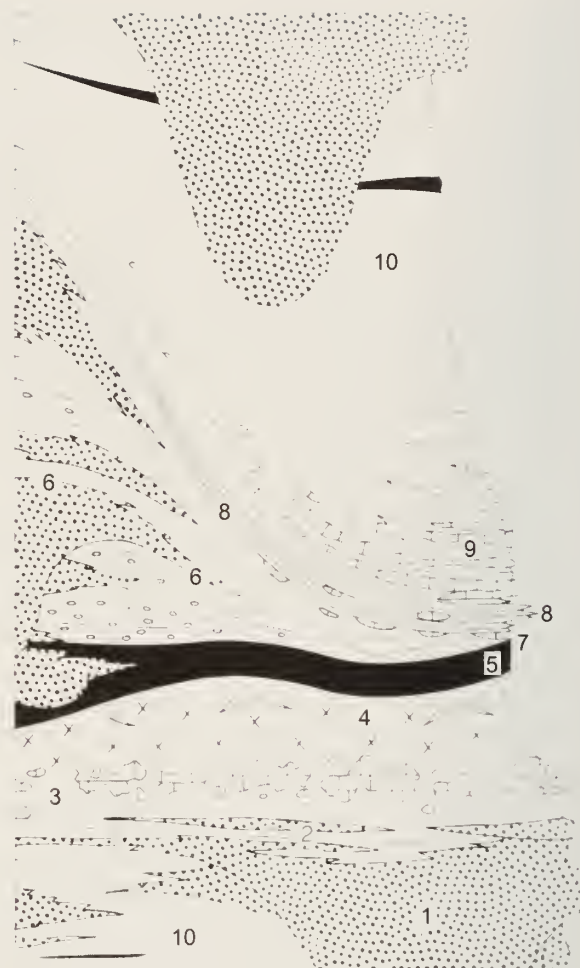
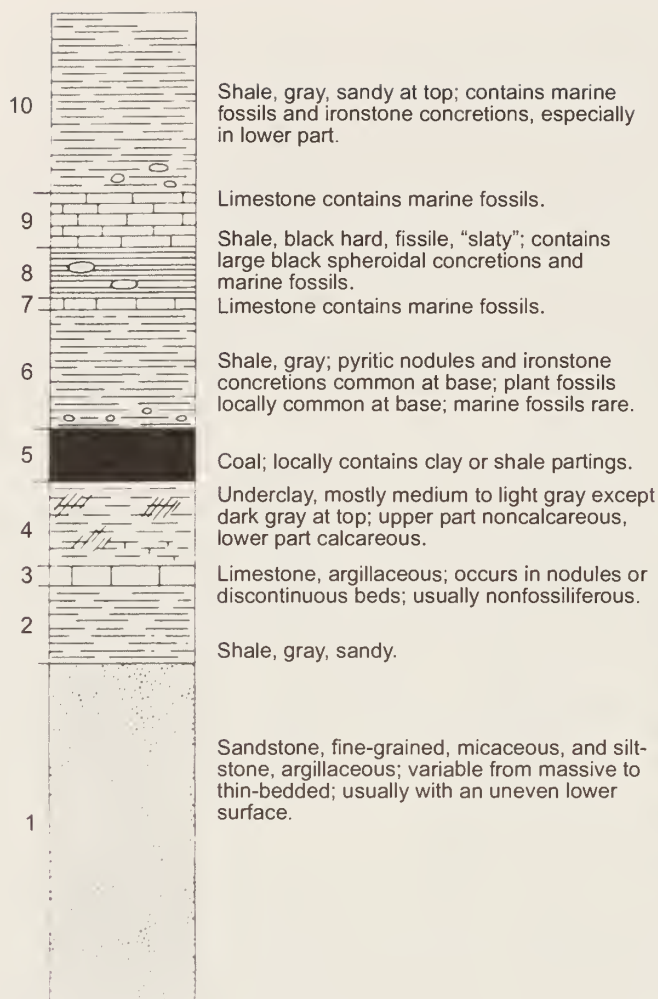
PENNSYLVANIAN CYCLOTHEMS

The Pennsylvanian strata exhibit extraordinary variations in thickness and composition both laterally and vertically because of the extremely varied environmental conditions under which they formed. In many places, individual sedimentary units are only a few inches thick, and only a few units exceed 30 feet thick. Sandstones and shales commonly grade laterally into each other, and shales may interfinger with and grade laterally and vertically into limestones and coals. The underclays, coals, black shales, and some limestones, however, display remarkable lateral continuity for such thin units. Some coal seams have been laterally traced (correlated) in mines, outcrops, and subsurface drill records over areas comprising several states.

The rapid and frequent changes in depositional environments during Pennsylvanian time produced regular or cyclical successions of sandstone, shale, limestone, and coal in response to the shifting shoreline. Each succession of these lithologies, called a cyclothem, consists of a series of marine and nonmarine rock units that record a complete cycle of marine invasion and retreat. Geologists have determined, after extensive studies of the Pennsylvanian strata in the Midwest, that an “ideally” complete cyclothem consists of ten sedimentary units (see illustration on following page contrasting the model of an “ideal” cyclothem with a model showing the dynamic relationships between the various members of a typical cyclothem).

Approximately 50 cyclothems have been described in the Illinois Basin, but only a few contain all ten units at any given location. Generally, one or more of the expected units are missing because conditions of deposition were more varied than indicated by the “ideal” cyclothem. However, the order of units in each cyclothem is almost always the same: a typical cyclothem includes a basal sandstone overlain by an underclay, coal, gray shale, black sheety shale, marine limestone, and gray marine shale. In general, the sandstone-underclay-coal-gray shale portion (the lower units) of each cyclothem is nonmarine: it was deposited as part of the coastal lowlands from which the sea had withdrawn. However, some of the sandstones are entirely or partly marine. The units above the coal and gray shale are marine sediments deposited when the sea advanced over the coastal plain.





The idealized cyclothem at left (after Willman and Payne, 1942) implies continuous, widespread distribution of individual cyclothem units. At right, the model of a typical cyclothem (after Baird and Shabica, 1980) shows the laterally discontinuous nature of many units in a cyclothem.

ORIGIN OF COAL AND ASSOCIATED SEDIMENTS

It is generally accepted that the Pennsylvanian coals originated by the accumulation of vegetable matter, normally in place, in extensive, fresh- to brackish-water swamps. They represent the last deposits of the nonmarine portion of a cyclothem. The swamps occupied vast areas of the coastal lowland, which bordered the shallow Pennsylvanian sea. A luxuriant growth of forest plants, many quite different from those of today, flourished in the warm, humid Pennsylvanian climate. The deciduous trees and flowering plants that are common today had not yet evolved. Instead, the jungle-like forests were dominated by giant ancestors of present-day club mosses, horsetails, ferns, conifers, and cycads. The undergrowth also was well developed, consisting of many ferns, fernlike plants, and small club mosses. Most of the plant fossils found in the coals and associated sedimentary rocks show no annual growth rings, pointing to the rapid growth rates and lack of seasonal climatic variations typical of tropical lowland areas. Many of the Pennsylvanian plants, such as the seed ferns, eventually became extinct.

Plant debris from the rapidly growing swamp forests—leaves, twigs, branches, and logs—accumulated as thick mats of peat on the floors of the swamps. Normally, vegetable matter rapidly decays by oxidation, forming water, nitrogen, and carbon dioxide. However, conditions within these ancient swamps, which were probably low in oxygen, prevented oxidation, and any decay of the peat deposits was due primarily to bacterial action.

Periodic invasions of the Pennsylvanian sea across the coastal swamps killed the forests, and the coals were commonly buried by marine sediments. During and after the marine transgressions, the peat generally became saturated with sea water containing sulfates and other dissolved minerals. The marine sediments deposited on top of the drowned peat also were saturated with sea water, which further infiltrated the peat. As a result, wherever the peat was buried by marine sediments, the coal that eventually formed from it is high in sulfur. However, in a number of areas, nonmarine muds, silts, and sands from the river system on the coastal plain were deposited on the peat where flooding broke through natural levees or the river changed its course. Where these sediments (unit 6 of the cyclothem) directly overlie the coal and are more than 20 feet thick, we find that the coal is low in sulfur. Although the seas eventually covered the areas where these nonmarine, fluvial sediments overlay the peat, the peat was protected from most sulfur infiltration by these thick fluvial sediments.

As the basin continued to subside and more and more layers of sediment accumulated, the peat deposits were gradually transformed into coal by slow physical and chemical changes in which pressure (compaction by the enormous weight of overlying sedimentary layers), heat (also due to deep burial), and time were the most important factors. Water and volatile substances (nitrogen, hydrogen, and oxygen) were slowly driven off during the coal-forming ("coalification") process, and the peat deposits were changed into coal.

Coals have been classified by ranks that are based on the degree of coalification. The commonly recognized coals, in order of increasing rank, are (1) brown coal or lignite, (2) subbituminous, (3) bituminous, and (4) anthracite. Each increase in rank is characterized by larger amounts of fixed carbon and smaller amounts of oxygen and other volatiles in the coal. The hardness of coal also increases with increasing rank. All Illinois coals are classified as bituminous.

Underclays occur beneath most of the coals in Illinois. Because underclays are generally unstratified (unlayered), are leached to a bleached appearance, and generally contain plant roots, many geologists consider that they represent the ancient soils on which the coal-forming plants grew.

The exact origin of the carbonaceous black shale that occurs above many coals is uncertain. Under current thinking, the black shale is interpreted to represent the deepest part of the marine transgression. Maximum transgression of the sea was coupled with upwelling of nutrient-rich ocean water near the edge of the continental shelf and the accumulation of mud and animal remains on an ocean floor that became depleted of oxygen by the decay of the organic matter. This led to the deposition of black organic mud over vast areas stretching from Texas to Illinois. Deposition occurred in quiet-water areas where very fine-grained, iron-rich mud and finely disseminated plant debris were washed in from the land. Most of the fossils found in the black shale represent planktonic (floating) and nektonic (swimming) forms—not benthonic (bottom-dwelling) forms. The depauperate (dwarf) fossil forms previously reported in black shale in some places were thought to have been forms that were stunted by toxic conditions in the sulfide-rich, oxygen-deficient water of the lagoons. However, recent study has shown that this "depauperate" fauna actually consists mostly of normal-size individuals of species that never grew any larger.

REFERENCES

- Baird, G.C., and C.W. Shabica, 1980, The Mazon Creek depositional event; examination of Francis Creek and analogous facies in the Midcontinent region: *in* Middle and Late Pennsylvanian Strata on Margin of Illinois Basin, Vermilion County, Illinois, Vermillion and Parke Counties, Indiana (R. L. Langenheim, editor). Annual Field Conference—Society of Economic Paleontologists and Mineralogists. Great Lakes Section, No. 10, p. 79–92.
- Cobb, J.C., and C.B. Cecil, eds., 1993, Modern and Ancient Coal-Forming Environments: Geological Society of America Special Paper 286, 198 p.
- Heckel, P.H., 1977, Origin of phosphatic black shale facies in Pennsylvanian cyclothem of mid-continent North America: American Association of Petroleum Geologist Bulletin, v. 61, p. 1045–1068.



Kosanke, R.M., J.A. Simon, H.R. Wanless, and H.B. Willman, 1960, Classification of the Pennsylvanian Strata of Illinois: Illinois State Geological Survey Report of Investigation 214, 84 p.

Simon, J.A., and M.E. Hopkins, 1973, Geology of Coal: Illinois State Geological Survey Reprint 1973-H, 28 p.

Willman, H.B., and J. N. Payne, 1942, Geology and Mineral Resources of the Marseilles, Ottawa, and Streator Quadrangles: Illinois State Geological Survey Bulletin 66, 388 p.


Willman, H.B., et al., 1967, Geologic Map of Illinois: Illinois State Geological Survey map; scale, 1:500,000 (about 8 miles per inch).

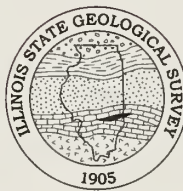
Willman, H.B., E. Atherton, T.C. Buschbach, C.W. Collinson, J.C. Frey, M.E. Hopkins, J.A. Lineback, and J.A. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey Bulletin 95, 261 p.

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Quaternary Glaciations in Illinois

ORIGIN OF THE GLACIERS

Over the past 1.6 million years, known as the Quaternary (kwa-TURN-ah-ree) Period of geologic time, most of the northern hemisphere above the 50th parallel was repeatedly covered by glacial ice. The cooling of the earth's surface began at least 2 million years ago, and with that cooling, ice sheets eventually formed in sub-arctic regions and spread outward until they covered the northern parts of North America. With ongoing climatic change during this period, these ice sheets would form and reform many times.

Early studies of the glaciated landscape concluded that four separate glacial episodes had occurred in North America. The deposits from each episode were separated from each other by buried soils, which formed on the land during warmer intervals between glaciations. More recent studies have shown that there were more than four glaciations, but the actual number is not yet known. These studies, based on buried soils and glacial deposits, estimate 4 to 8 episodes of ice advance and melting over Illinois. We now know that the older glacial sediments are more complex than originally thought and probably represent more than one episode. Until we know more, all of the glacial deposits before the Illinois Episode (from 300,000 to 125,000 years ago) are classified as pre-Illinoian deposits.

The North American ice sheets developed when the mean annual temperature was perhaps 4° to 7°C (7° to 13°F) cooler than it is now and winter snows did not completely melt during the summers. Because this time of cooler conditions lasted tens of thousands of years, thick masses of snow and ice accumulated to form glaciers. As the ice thickened, the great weight of the ice and snow caused the glaciers to flow outward at their margins, in several instances for hundreds of miles. As the ice sheets expanded, the areas in which snow accumulated probably also increased in extent.

Several times, huge tongues of ice, called lobes, flowed southward from two different centers, one east and one west of present-day Hudson Bay, and converged in the central lowland between the Appalachian and Rocky Mountains. There the glaciers made their farthest advances to the south. The sketch at right shows the centers of flow, the general directions of flow from the centers, and the southern extent of glaciation. Because Illinois lies entirely in the central lowland, it was invaded by lobes from both accumulation centers.



EFFECTS OF GLACIATION

Quaternary glaciers and the waters melting from them changed the landscapes they covered. The glaciers scraped and smeared the landforms they overrode, leveling and filling many of the minor valleys and even some of the larger ones. Moving ice carried colossal amounts of rock and earth, commonly for hundreds of miles; the glaciers scoured the land surface and kneaded much of the rock debris into the moving ice.

The continual floods of glacial meltwaters entrenched new drainageways and deepened old ones, and partly refilled them with the great quantities of rock and earth carried by the glaciers. According to some estimates, the amount of water that was drawn from the sea and changed into ice during a glacial episode lowered the sea level by 300 to 400 feet below its present level. When these continental ice sheets melted, tremendous volumes of water eroded and transported sediments.



In most of Illinois, glacial and meltwater deposits buried the previous rocky, low, hill-and-valley terrain and created the flatter landforms that became our prairies. The glaciers deposited across roughly 90% of the state a mantle of ground-up rock debris, gravel, sand, and clay that at points reaches thicknesses of 400 to 500 feet. These deposits are of incalculable value to Illinois residents because they are the parent material of our rich soils, the source of drinking water for much of the state, and provide large amounts of sand and gravel for construction.

GLACIAL DEPOSITS

Drift is the term for all the deposits of earth and rock materials moved by glacial activity. **Till** is the type of drift deposited directly by glacial ice. Because till was not moved much by water, this sediment is unsorted, containing particles of many different sizes and compositions. It is also unstratified (unlayered). A till may contain materials ranging in size from microscopic clay particles to large boulders. Most tills in Illinois are pebbly clays with only a few boulders. For descriptive purposes, a mixture of clay, silt, sand, and boulders is called **diamicton**. This term describes a deposit that could be interpreted as till or as a product of a different process called mass wasting, which includes such things as rockslides or other similar gravity-propelled earth movements.

End moraines are the arc-shaped ridges that formed when till piled up along a glacier's leading edge when the ice was melting at roughly the same rate as the flowing ice moved forward. Till also formed **ground moraines**, or **till plains**, which have gently undulating surfaces formed as the ice front melted back. Deposits of till identify areas once covered by glaciers. The many alternating ridges and plains in northeastern Illinois are the successive end moraines and till plains formed by the retreating Wisconsin Episode glaciers (about 25,000 to 13,500 years ago).

Outwash is the sorted and stratified sediments deposited by meltwater flowing away from the glacier. Outwash deposits are layered in beds because the flow of water that moved the material varied in gradient, volume, velocity, and direction. As a meltwater stream carried the rock materials along, it sorted them by size. As stream velocity decreased, heavier gravels and cobbles were deposited before fine sands, silts, and clays, which were deposited farther downstream. Typical Quaternary outwash in Illinois consists of multilayered beds of sands and gravels and some silts. These beds look much like modern stream deposits in some places. Outwash tends to be coarser and less weathered than stream sediment (alluvium), which is generally finer than medium sand and contains variable amounts of weathered rock debris.

Meltwater deposits are found not only in the area once covered by the glaciers but also in areas far beyond it. Meltwater streams ran off the top of the glacier, in crevices within the ice, and under the ice. In some places, the cobble-gravel-sand filling of the bed of a stream that flowed within or under the ice is preserved as a sinuous ridge called an **esker**. Some eskers in Illinois are made up of sandy, silty, gravelly deposits and contain mass-wasted diamicton material. Cone-shaped mounds of coarse outwash, called **kames**, were formed where meltwater plunged through crevasses in the ice.

The finest outwash sediments, the silts and clays, formed bedded deposits in the ponds and lakes that filled glacier-dammed stream valleys, the low-lying areas on till plains, and some low till plains where meltwaters were diked behind end moraines. Meltwater streams that entered a lake rapidly lost velocity and dropped the sands and gravels they carried, forming deltas at the edge of the lake. Very fine sands and silts were commonly redistributed on the lake bottom by wind-generated currents, and the clays, which stayed in suspension longest, slowly settled out and accumulated with them.

Along the ice front, meltwater ran off in innumerable shifting, cross-cutting, and short-lived streams (called braided streams), which laid down an **outwash plain**, a broad, flat blanket of outwash. Outwash was also carried away from the glaciers in valleys cut by floods of meltwater. The Mississippi, Illinois, and Ohio Rivers occupy valleys that were major channels for meltwaters and that were greatly widened and deepened during the greatest meltwater floods. When the floods waned, these valleys were partly filled with outwash far beyond the ice margins. Such outwash deposits, largely sand and gravel, are known as **valley trains**. Valley train deposits may be both extensive and thick. For instance, the long valley train of the Mississippi River Valley is up to 200 feet thick in places.

LOESS, EOLIAN SAND, AND SOILS


One of the most widespread types of sediment resulting from glaciation was carried not by ice or water, but by wind. **Loess** (rhymes with “bus”) is the name given to windblown deposits dominated by silt-sized particles. Most of the silt was derived from wind erosion of the valley trains. Wind action also sorted out sand, which commonly formed **sand dunes** on the valley trains or on the adjacent uplands. In places, sand dunes have migrated up to 10 miles away from the principal source of sand. Flat areas between dunes are generally underlain by **eolian** (windblown) **sand** that was usually reworked by water action. On uplands along the major valley trains, loess and eolian sand are commonly interbedded. With increasing distance from the valleys, the eolian sand thins and disappears, often within one mile from the valleys.

Eolian deposition occurred when certain climatic conditions, most likely following a seasonal pattern, were met. Deposition was probably in the fall, winter, or spring when low precipitation volumes and low temperatures caused meltwater floods to abate, exposing the surfaces of the valley trains and permitting them to dry out. Throughout the Quaternary Period, prevailing westerly winds deposited loess more thickly on the east sides of the source valleys. Although the loess thins rapidly away from the valleys, it extends over almost all of Illinois.

Each glacial episode was followed by an interglacial episode that began when the climate warmed enough to melt the glaciers and their snowfields. During these warmer intervals, when the climate was similar to that of today, drift and loess surfaces were exposed to weather and the activities of living things. Consequently, over most of the glaciated terrain, soils developed on the glacial deposits and altered the composition, color, and texture of the deposits. Such soils were generally destroyed by later glacial advances, but some were buried. Those that survive serve as “key beds,” or stratigraphic markers, and are evidence of the passage of a long interval of time.

*Contributed by Dwain J. Berggren
Revised January 2000 by Myrna M. Killey*

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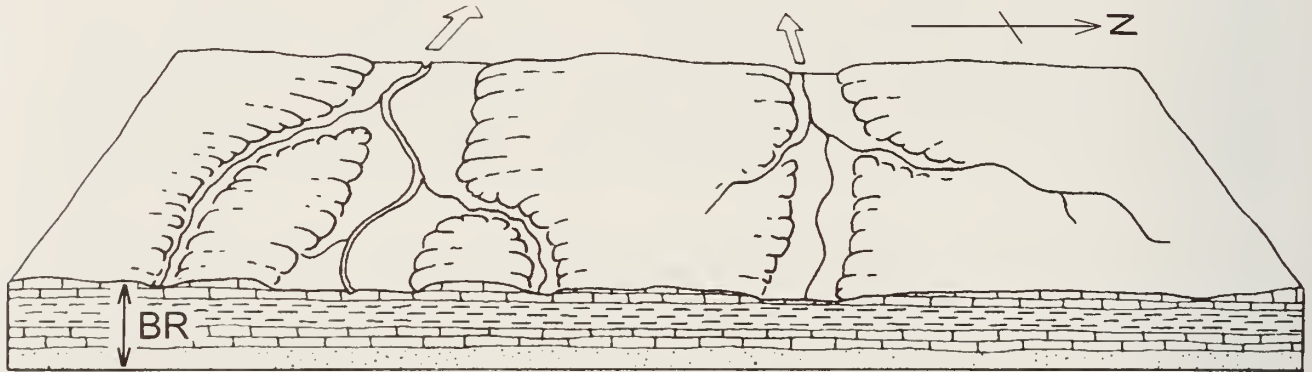
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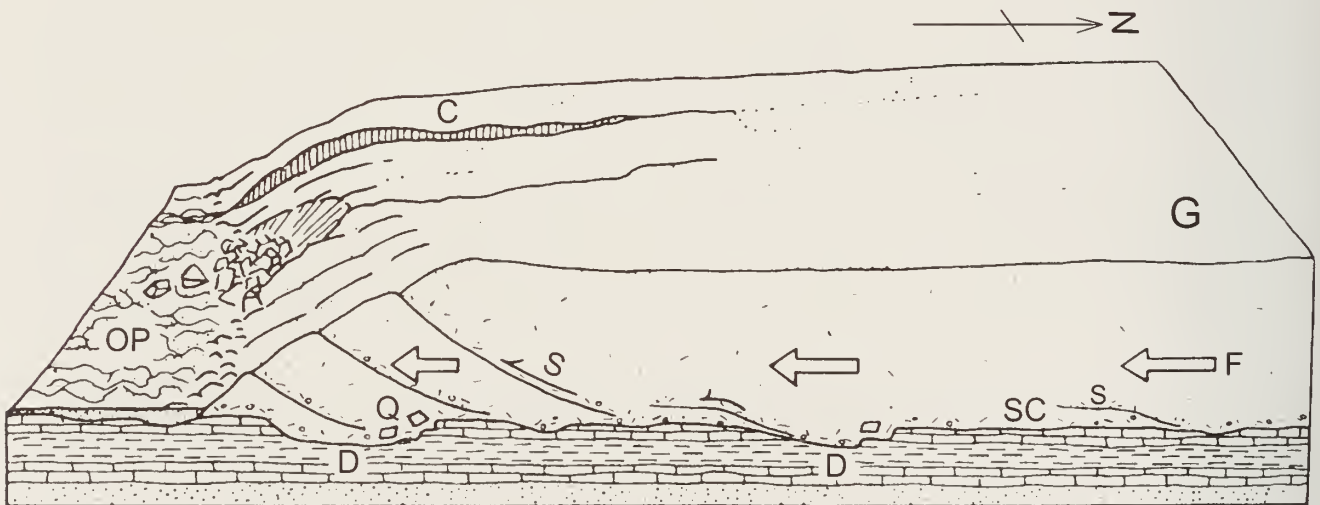
GLACIATION IN A SMALL ILLINOIS REGION

These diagrams show how a continental ice sheet might have looked at various stages as it moved across a small region in Illinois. The diagrams illustrate how the ice sheet could change the old terrain and create a landscape like the one we live on. To visualize how these glaciers looked, geologists study the landforms and materials left in the glaciated regions, as well as present-day mountain glaciers and polar ice caps.

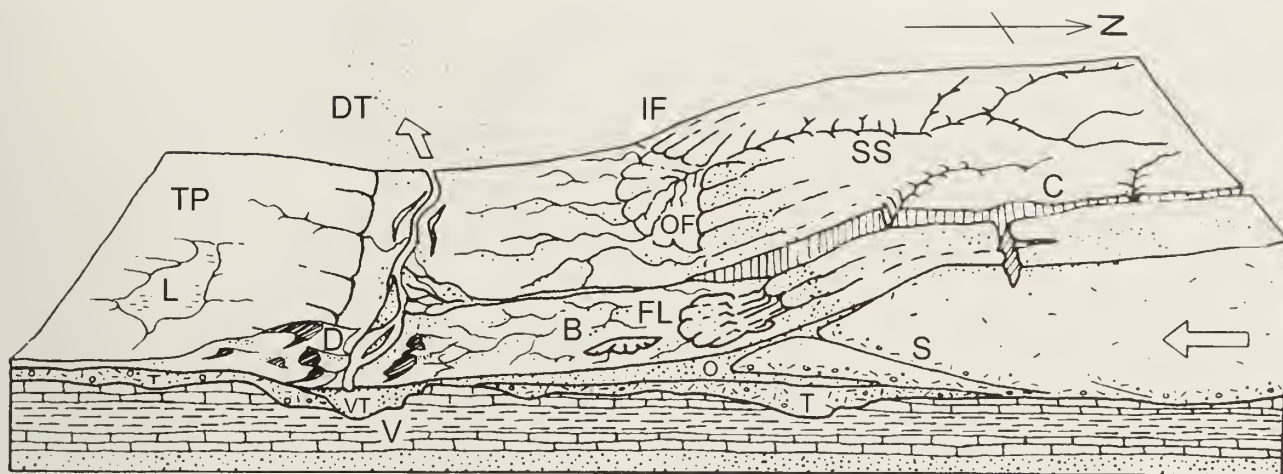
The block of land in the diagrams is several miles wide and about 10 miles long. The vertical scale is exaggerated; layers of material and landforms are drawn proportionally thicker and higher than they actually are so that they can be easily seen.



1 The Region before Glaciation — Like most of Illinois, the region illustrated is underlain by almost flat-lying beds of sedimentary rocks—layers of sandstone (stippled), limestone (horizontal lines), and shale (vertical lines). Millions of years of erosion have planed down the bedrock (BR), creating a terrain of low uplands and shallow valleys. A residual soil weathered from local rock debris covers the area but is too thin to be shown in the drawing. The streams illustrated here flow westward and the one on the right flows into the other at a point beyond the diagram.



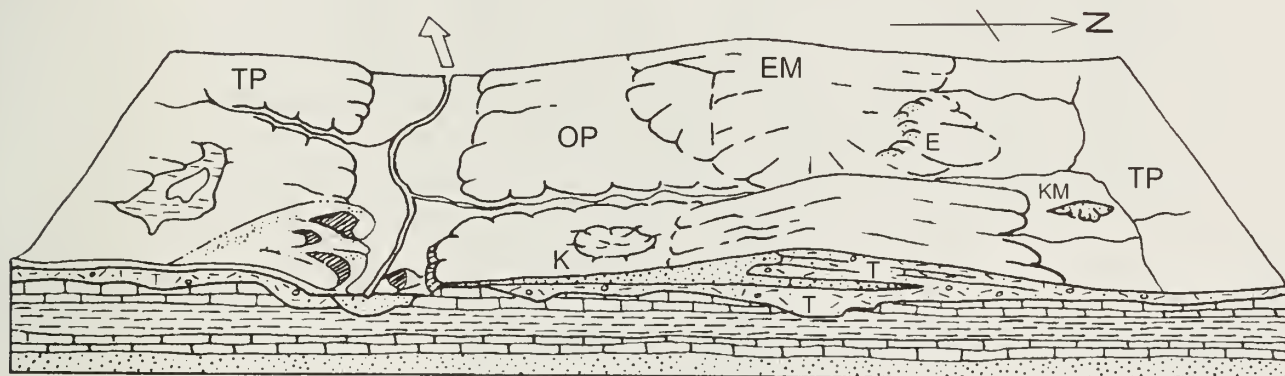
2 The Glacier Advances Southward — As the glacier (G) spreads out from its ice snowfield accumulation center, it scours (SC) the soil and rock surface and quarries (Q)—pushes and plucks up—chunks of bedrock. The materials are mixed into the ice and make up the glacier's "load." Where roughness in the terrain slows or stops flow (F), the ice "current" slides up over the blocked ice on innumerable shear planes (S). Shearing thoroughly mixes the load. As the glacier spreads, long cracks called "crevasses" (C) open parallel to the direction of ice flow. The glacier melts as it flows forward, and its meltwater erodes the terrain in front of the ice, deepening (D) some old valleys before ice covers them. Meltwater washes away some of the load freed by melting and deposits it on the outwash plane (OP). The advancing glacier overrides its outwash and in places scours much of it up again. The glacier may be 5,000 or so feet thick in Canada and tapers to the margin, which was probably in the range of several hundred feet above the old terrain. The ice front advances perhaps as much as a third of a mile per year.



3 The Glacier Forms an End Moraine — A warming climate halts the glacier advance across the area, and the ice begins to melt as fast as it advances. The ice front (IF) is now stationary, or fluctuating in a narrow area, and the glacier is forming an end moraine.

As the top of the glacier melts, some of the sediment that is mixed in the ice accumulates on top of the glacier. Some is carried by meltwater onto the sloping ice front (IF) and out onto the plain beyond. Some of the debris slips down the ice front in a mudflow (FL). Meltwater runs through the ice in a crevasse (C). A supraglacial stream (SS) drains the top of the ice, forming an outwash fan (OF). Moving ice has overridden an immobile part of the front on a shear plane (S). All but the top of a block of ice (B) is buried by outwash (O).

Sediment from the melted ice of the previous advance (figure 2) remains as a fill layer (T), part of which forms the till plain (TP). A shallow, marshy lake (L) fills a low place in the plain. Although largely filled with drift, the valley (V) remains a low spot in the terrain. As soon as the ice cover melts, meltwater drains down the valley, cutting it deeper. Later, outwash partly refills the valley: the outwash deposit is called a valley train (VT). Wind blows dust (DT) off the dry floodplain. The dust will form a loess deposit when it settles. Sand dunes (D) form on the south and east sides of streams.

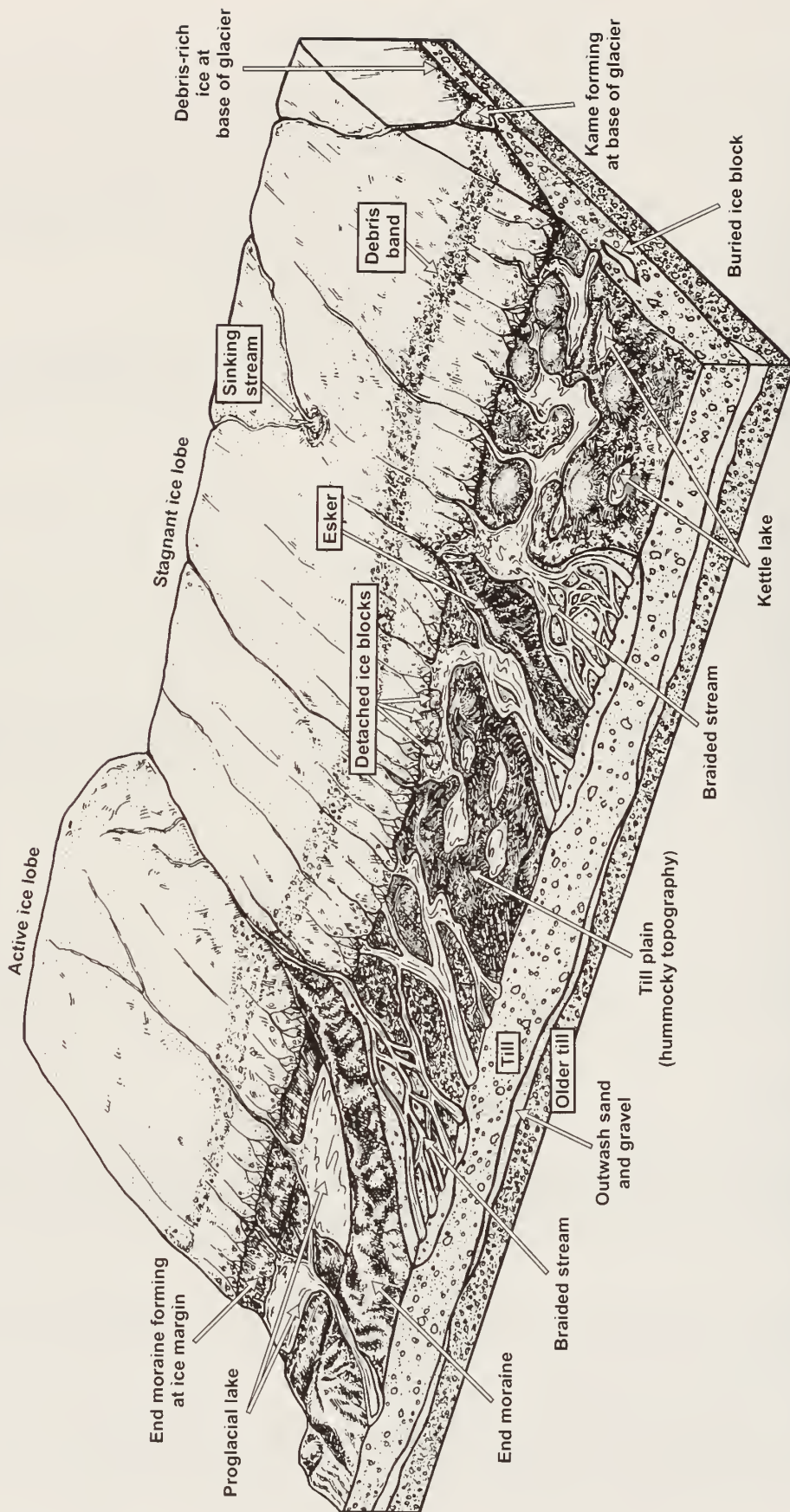


4 The Region after Glaciation — As the climate warms further, the whole ice sheet melts, and glaciation ends. The end moraine (EM) is a low, broad ridge between the outwash plain (OP) and till plains (TP). Run-off from rains cuts stream valleys into its slopes. A stream flows through the end moraine along the channel cut by the meltwater that ran out of the crevasse in the glacier.

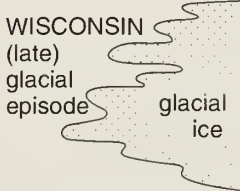
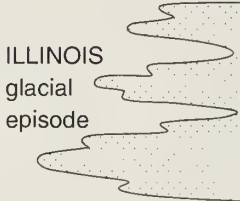
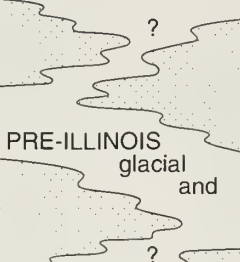
Slopewash and vegetation are filling the shallow lake. The collapse of outwash into the cavity left when the ice block melted has formed a kettle (K). The outwash that filled a tunnel draining under the glacier is preserved in an esker (E). The hill of outwash left where meltwater dumped sand and gravel into a crevasse or other depression in the glacier or at its edge is a kame (KM). A few feet of loess covers the entire area but cannot be shown at this scale.



Continental Glacier



TIMETABLE OF EVENTS IN THE ICE AGE IN ILLINOIS

Years before present	Time-distance diagram Interglacial and glacial episodes	Sediment record	Dominant climate conditions Dominant land forming and soil forming events
HOLOCENE	interglacial episode	River, lake, wind, and slope deposits.	Warm; stable landscape conditions. Formation of modern soil; running water, lake, wind, and slope processes.
10,000	 <p>WISCONSIN (late) glacial episode</p> <p>glacial ice</p>	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable landscape conditions. Glacial deposition, erosion, and landforming processes (e.g., formation of end moraines, outwash plains, valley trains, proglacial lakes, kettles), plus running water, lake, wind, and slope processes.
25,000			
75,000	WISCONSIN (early and middle) glacial margin north of Illinois	Loess; river, lake, and slope deposits.	Cool; stable. Weathering, soil formation (Farmdale Soil and minor soils); wind and running water processes.
125,000	SANGAMON interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Weathering, soil formation (Sangamon Soil); running water, lake, wind, and slope processes.
300,000	 <p>ILLINOIS glacial episode</p>	Till and ice-marginal deposits; outwash and glacial lake deposits; loess.	Cold; unstable. Glacial deposition, erosion, and land-forming processes, plus proglacial running water, lake, wind, and slope processes; possible minor soil formation.
425,000			
1,600,000 and older	YARMOUTH interglacial episode	River, lake, wind, and slope deposits.	Warm; stable. Long weathering interval with deep soil formation (Yarmouth Soil); running water, lake, wind, and slope processes.
	 <p>PRE-ILLINOIS glacial and</p> <p>interglacial episodes</p>	Till and ice-marginal deposits; outwash and glacial lake deposits; loess plus nonglacial river, lake, wind, and slope deposits.	Alternating stable and unstable intervals of uncertain duration. Glacial deposition, erosion, and land-forming processes, plus proglacial and interglacial running water, lake, wind, and slope processes; interglacial weathering and soil formation.



SEQUENCE OF GLACIATIONS AND INTERGLACIAL DRAINAGE IN ILLINOIS



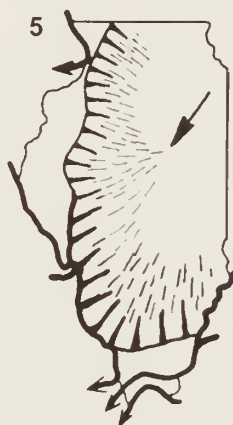
1
PRE-PLEISTOCENE
major drainage



2
PRE-ILLINOIS
inferred glacial limits



3
YARMOUTH
major drainage



4 5 6
ILLINOIS
extent of three glacial advances



7
SANGAMON
major drainage



8
WISCONSIN
(early and middle)
glacial margin
north of Illinois



9
maximum
glacial advance



10
WISCONSIN (late)
ice and
Kankakee Flood




11
drainage
glacial lakes

Quaternary Deposits of Illinois


Hudson and Wisconsin Episodes

Mason Group and Cahokia Fm

 Cahokia and Henry Fms; sorted sediment including waterlain river sediment and windblown and beach sand


 Equality Fm; fine grained sediment deposited in lakes


Wedron Group (Tiskilwa, Lemont, and Wadsworth Fms) and Trafalgar Fm; diamicton deposited as till and ice-marginal sediment


 End moraine

 Ground moraine


Illinois Episode

 Winnebago Fm; diamicton deposited as till and ice-marginal sediment


 Glasford Fm; diamicton deposited as till and ice-marginal sediment

 Teneriffe Silt and Pearl Fm, including Hagerstown Mbr; sorted sediments including river and lake deposits and wind blown sand

Pre-Illinois Episodes

 Wolf Creek Fm; predominantly diamicton deposited as till and ice-marginal sediment

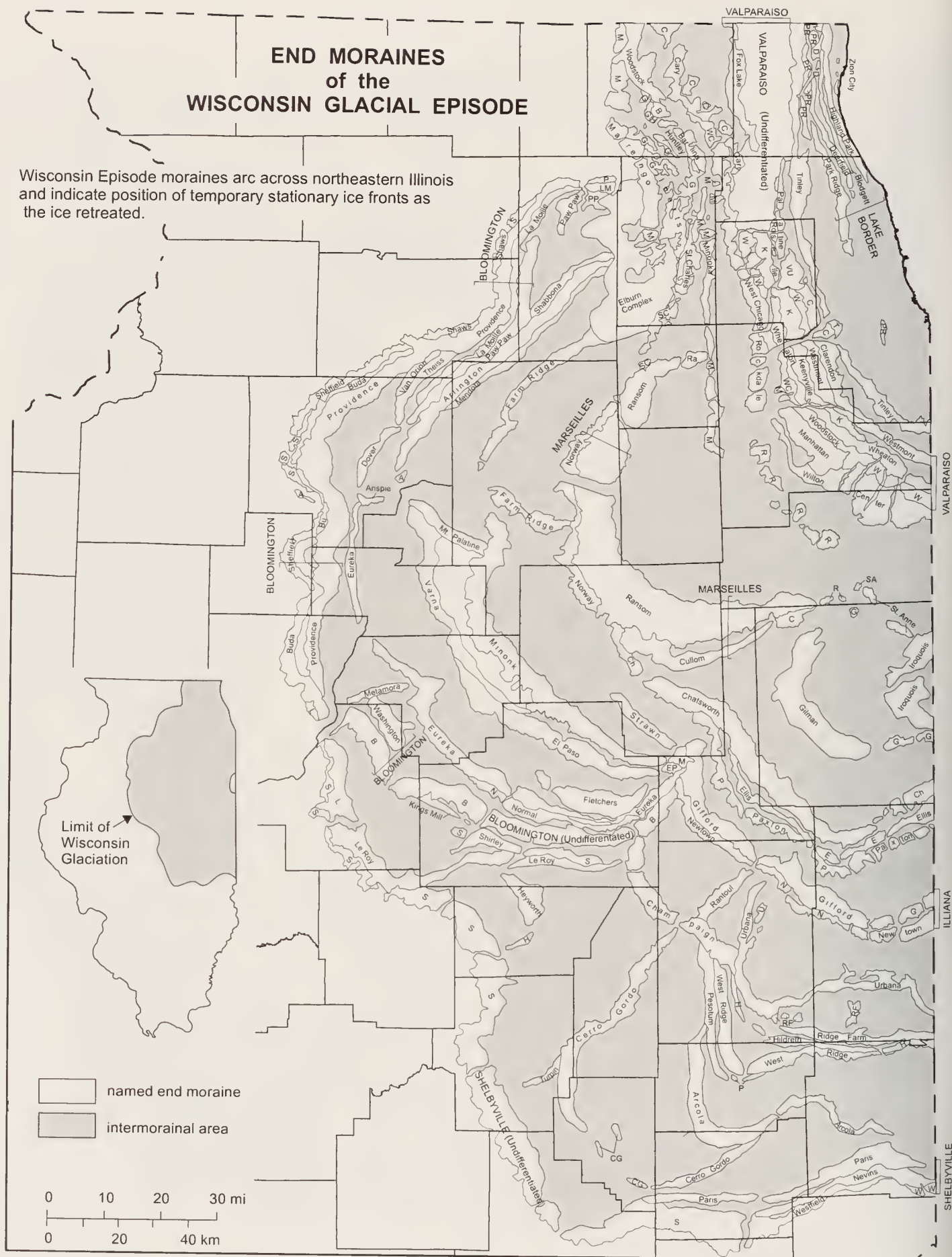
Paleozoic, Mesozoic, and Cenozoic

 Mostly Paleozoic shale, limestone, dolomite, or sandstone; exposed or covered by loess and/or residuum



END MORAINES of the WISCONSIN GLACIAL EPISODE

Wisconsin Episode moraines arc across northeastern Illinois and indicate position of temporary stationary ice fronts as the ice retreated.



Fluorite—Illinois' State Mineral

Deep purple, amethyst, sky blue, sea green, sunny yellow, and crystal clear—the mineral fluorite comes in all colors. Many types of fluorite even glow under ultraviolet light. They're "fluorescent."

Pure fluorite (CaF_2), made of the elements calcium (Ca) and fluorine (F), is colorless. The various colors result from tiny amounts of other elements substituting for the calcium in the crystalline structure.

Transparent to translucent, this glass-like mineral may be found as irregular masses filling veins that cut through rocks, or in flat-lying bands or layers parallel with the bedding planes of sedimentary rocks. As the photos show, fluorite also forms as clusters of beautiful cubic crystals.

Light reflects strongly from fluorite's crystal faces and cleavage surfaces, which can be polished to a high luster. As lovely as a gemstone, fluorite is brittle and relatively soft (4 on Moh's hardness scale), so it's unsuitable for ring settings. Brooches and pendants must be handled carefully to avoid scratching or fracturing the mineral specimens in these settings.

Just for display, miners chipped octahedrons out of coarse crystals of the mineral known to the mining industry as *fluorspar*. They called the eight-sided crystals "diamonds."

How did Illinois' fluorite deposits form?

Hot water containing fluorine and other dissolved chemicals rose from deep in the earth during the Jurassic Period, about 150 to 200 million years ago. The water flowed through northeast-trending faults and fractures in limestones laid down earlier in the Mississippian Period, about 330 million years ago.

When the hot brines reached the calcium-rich Mississippian rocks, the temperature and other conditions were just right for crystallizing fluorite along the walls of the faults and in flat-lying layers parallel to the beds of limestone. These host rocks dissolved and were replaced with the fluorite.

Country's leading producer of fluorspar

Since the early 1800s, fluorite has been mined in southeastern Illinois. The fluorspar-rich region, which reaches from southeastern Illinois into parts of Kentucky, was called the Illinois-Kentucky Fluorspar Mining District.

In Illinois, fluorite was mined almost exclusively in Hardin and Pope Counties. The main production came from fissure-vein deposits in the Rosiclare district, and stratiform (bedding plane) deposits in the Cave in Rock district (map, p. 2). Other areas in the two counties yielded smaller amounts of the mineral.

Most mining was underground, as much as 1,300 feet deep. But open-pit mines operated where fluorite deposits intersected land surface.

Illinois displaced Kentucky as the country's leading producer of fluorite in 1942. For many years, Illinois accounted for more than 50% of total U.S. fluorspar production. But by 1990, more than 90% of the fluorite used in the U.S. was imported. Illinois was the only remaining domestic producer.

Competition from foreign producers coupled with high costs of underground operations made Illinois' fluorspar mining unprofitable. The last fluorspar mine in Illinois closed in December 1995. Fluorspar is no longer mined anywhere in the United States.



Illinois' State Mineral The General Assembly made fluorite the State Mineral in 1965, when fluorspar mining was a multimillion-dollar-per-year industry in Illinois. Over the years, much more fluorite has been mined in Illinois than in any other state.

The many uses for fluorite

Native Americans carved fluorspar to make artifacts, but the first recorded use of Illinois' fluorite was in 1823, when fluorspar mined near Shawneetown in Gallatin County was used to manufacture hydrofluoric acid.

The mineral, fluorite, is vital to the nation's economy. Its uses:

Mineral

- smelting iron, aluminum, and other metal alloys,
- manufacturing glass, enamel glazes, ceramics, portland cement, and many chemical compounds.

Hydrofluoric acid

- refining aluminum,
- refining uranium fuel for nuclear reactors,
- making rocket fuel and metal plating.

Inorganic fluoride chemicals

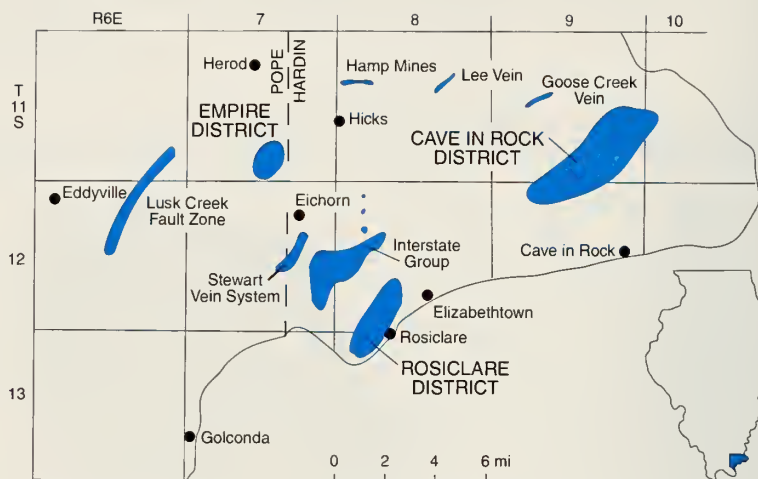
- toothpastes, special fluxes for welding rods, optical lenses, and concrete hardeners.

Organic fluoride chemicals

- Plastics, refrigerants, nonstick coatings, lubricants, stain repellents, dyes, herbicides, medicines and anesthetics, cleaning solvents, degreasing agents and foaming agents.

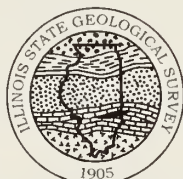
One of the most widely used organic fluoride compounds, the refrigerant Freon 12®, is no longer produced in the United States. The chlorine in the compound is thought to damage the protective ozone layer that shields the earth from ultraviolet radiation.

Contributed by D.L. Reinertsen and J.M. Masters



Principal mining areas in the southeastern Illinois part of the Illinois-Kentucky Fluorspar Mining District.

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